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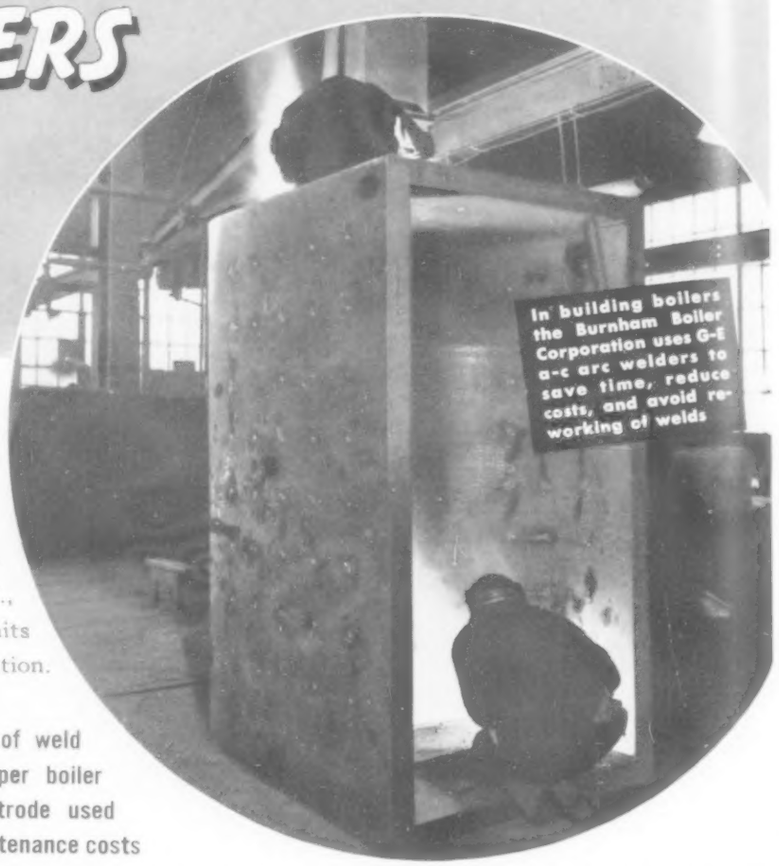
The Welding Journal

FEBRUARY, 1939

The Journal of the American Welding Society

CHANGE TO GENERAL ELECTRIC A-C WELDERS PAYS BIG DIVIDENDS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General Electric
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GENERAL ELECTRIC

The American Welding Society Journal

W. SPRARAGEN, Editor

Published for the Advancement of the Science and Art of Welding

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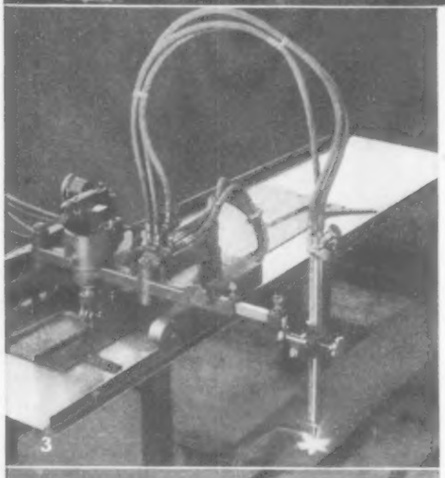
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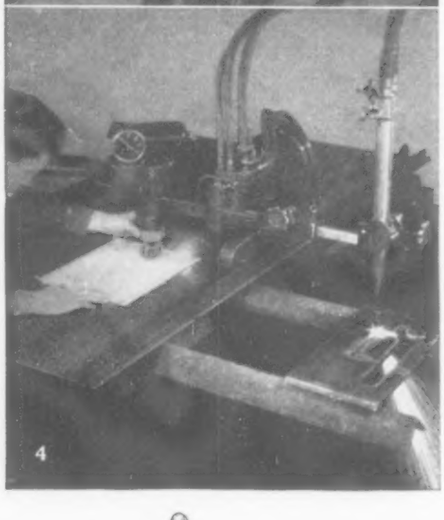
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1. CM-15 flame-cut parts made possible much of the strength and efficiency in the unit construction of this tractor.

2. These are some of the flame-cut tractor parts ready for assembly and fabrication.

3. Here the CM-15 is shaping one of the three steel channels that form the tractor frame and hold the rollers in alignment.

4. Innumerable small shapes such as wrenches can be quickly cut to size on the CM-15 Machine by hand tracing.

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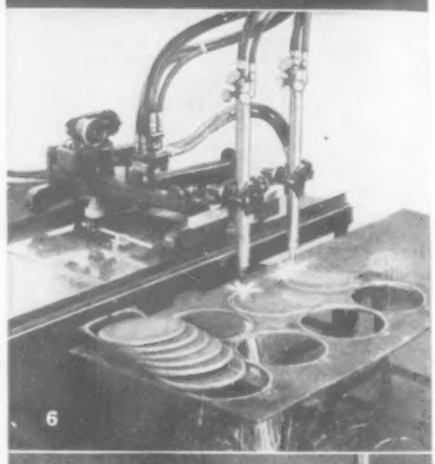
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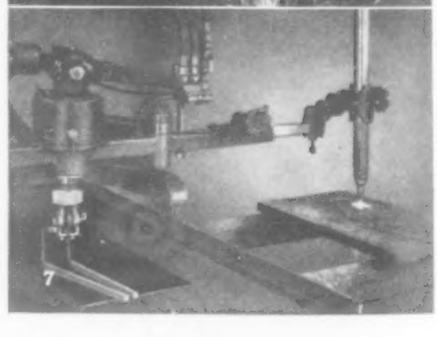
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Welding Journal

VOLUME 18, No. 2 FEBRUARY 1939

COMMERCIAL WELDERY*

By A. E. and M. W. GIBSON†

IN ANSWER to an inquiry as to whether we wished to quote on the fabrication of a welded lathe, we wrote the purchaser asking for the privilege of having an engineer call to discuss their requirements. The request was granted; our engineer called. With the aid of a book of photographs of actual weldments, and a brief description of our engineering, fabricating and research facilities, the engineer convinced the customer of our ability to accomplish the work successfully, and was given their written inquiry and drawings.

In the preparation of our estimate, we included in detail the weights and cost of the various materials required, the labor hours by departments carried out into labor and shop burden cost, the administration charge and the engineering and pattern development costs. To the summary of all these items, called the "cost," was added the profit expected and an item called "tax," which is equal to 1% (for 1937) of the selling price to cover the social security tax. The selling price was thus obtained. A proposition stating the conditions upon which we would be pleased to accept their order, was sent to the customer. In due time an order for the work was received. The proper papers for the shop were written; materials not in stock were ordered and production started.

Only that part of the cost estimate pertaining to the actual welding fabrication will be discussed here. To determine the material cost, the detail drawings were sent to the drafting room where draftsmen figured the gross weight of the metal required. In estimating the labor, each piece was broken up into various operations such as layout and templet labor, shearing, shaping on hydraulic presses or bending brakes, gas cutting, fitting for welding, welding, cleaning and chipping for appearance, painting and shipping. In estimating the welding time, the actual feet of welding required was ascertained. Knowledge of the number of feet of welding per hour obtained with similar weldments was the basis used for arriving at the welding labor hours.

A data sheet was written, and given to the shop, purchasing department and cost department. This sheet showed the material and labor listed in the estimate, and was used as a guide for purchases and shop control of labor.

The designer employed one of the most effective methods of cost reduction, not only to reduce welding labor, but to improve the appearance of the product; that is, the use of a bending brake or power press to bend metal, rather than welding two or more plates to obtain the desired shape.

All detail parts were stress relieved after welding and before machining, and were also sand-blasted for removal of scale. The completed lathe had all the welds ground, filled and painted. This procedure was specified by the customer, who desired a product comparable in appearance to that of any modern machine tool.

The welding labor overran the estimate by twenty hours, due to the insistence of our inspection department that larger fillet welds be made than were originally estimated. The total labor was fairly close to and within the estimate. However, a substantial saving in the cost of the labor-burden item was made, due to a total labor saving of 128 hours and because the actual labor and burden rate during the period the work was fabricated averaged $1.90 per hour instead of the estimated $2.03 per hour. The reduction of $80.00 in administration was the result of the lower actual hours; an administrative charge of 17½% of the labor and burden was used in the estimate. A saving in the cost of thermal stress relieving and sand blasting resulted from the lower prices obtained at the time of placing this work. A profit of more than 17% was realized on the order.

MANAGEMENT

The success of every weldery is built on the interest, belief in welding and encouragements of some one executive with authority to act. Regardless of the knowledge of the subject, and the enthusiasm for it among subordinates, little progress can be made unless an executive in the organization is keen for welding. The coordination of engineering and fabrication, the necessary expenditure for equipment and supplies, the ceaseless drive for efficiency in design and production, can only result from executive support. The lack of these essentials spells failure, or at best, produces but mediocre success.

Granting that they are convinced of the advantages of welded construction, the management should at once take steps to train some promising individual in the organization for the work, or failing that, they should employ a competent welding supervisor. A competent welding supervisor must be more than a good welding operator. He must have the ability to handle men. He must be firm in his insistence that a worker give a dollar's service for a dollar in pay, have a knowledge of welding costs, of strength of materials, of metallurgy, of

* The authors of this paper received the Grand Award, $13,941.33, of the $200,000 Program sponsored by the James F. Lincoln Arc Welding Foundation, Cleveland, Ohio, in which savings of $1,600,000,000 were shown available to industry by wider application of arc welding. (Abstract.)

† President and stockholder, respectively, The Wellman Engineering Co., Cleveland, Ohio.

Fig. 1—Making Two Parts at Once Cuts the Labor Cost in Half. This Is Easily Accomplished with a Gas Cutting Machine

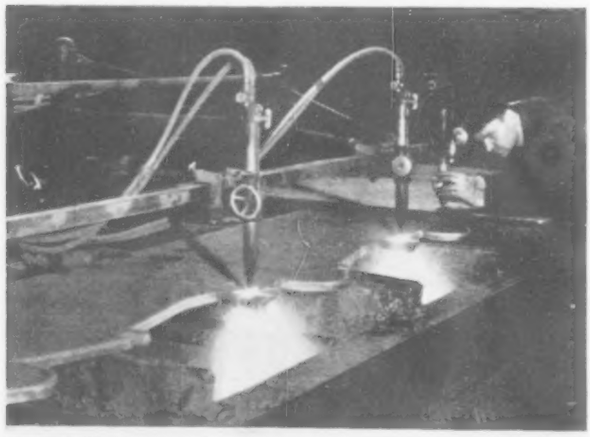


Fig. 2—No Successful Weldery Can Afford Not to Have Suitable Equipment for Positioning Work for Welding. Savings of from 10 to 30% in Welding Labor Are Possible with These Machines

metallography, of machining operations. He should have the knack of devising short-cuts and inexpensive appliances to facilitate work. He should keep in close touch with the actual hours of welding. A good welding supervisor should be alert in scrutinizing the appearance of welds to disclose defects, and should bring to the attention of the engineer suggested changes in design in order to better the product or to reduce the cost.

OPERATOR QUALIFICATION AND TRAINING

Operators are obtained in two ways: by training inexperienced applicants, and by hiring men who have had previous experience in other plants. In the former case, preference is given to a high school graduate who has had some machine tool experience. It is only when the operator can butt weld two $^1/_2$-inch plates, each Veed to 30°, without objectionable inclusions, gas pockets or lack of penetration, and produce true fillet welds in both flat and vertical positions which shall have the required tensile and ductility properties of filler metal, that he is permitted to perform our more important welding operations. The time needed to acquire sufficient skill is from four to six months.

When a rush of work requires the employment of experienced welders, we advertise by personally passing the information of our requirements through employees or through the newspapers. When a welder applies, we ask him if he is willing to make a qualifying butt weld test. The nick-break test is made in the presence of the applicant, and if the work is of such a nature that our supervisor feels that with a little practice the applicant can perform the test successfully, he is allowed further tests. This method of qualifying an operator has been questioned many times with the statement that a nick-break test does not measure either tensile strength or ductility. We have found, through years of experience with tensile, bend, fatigue, impact, hardness tests and metallographic investigations, that the nick-break test is by far the most difficult one to pass. Our judgment of an operator's ability from a nick-break test has not failed in over five years use, and too, this type of test can be made at practically no cost to the company, and of but one or two hours of the applicant's unemployed time.

Some of our operators have been qualified by the National Weld Test Bureau for welding unfired pressure vessels with plate thickness from $^5/_8$ inch to $1^1/_2$ inch. These welders have built a large number of pressure vessels under the supervision of insurance companies.

EQUIPMENT WELDING MACHINES

In view of the developments constantly being made in welding equipment, we believe five years is the extent of time a welding machine should be used. Not that the equipment is worn out in that period—we know of many welding machines which have been in continuous operation for 10 or 12 years—but that the developments perfected make it advisable to adopt this program. All our welding machines are depreciated over a period of five years and in turning them in on new equipment, no book loss is sustained.

It is our experience the D. C. welding machines are so sturdily built that little or no upkeep is necessary over the period they are kept in service in our shop. They are, however, periodically inspected by our electrical service men.

Electrodes.—While we know that welds made with bare wire are satisfactory in many fabrications not subjected to high stress, we have ruled out such wire solely because of the possibility of it being used in structures where shock and high stresses will be encountered. The electrode cost is so small a part of the over-all cost of welding that the added ductility secured by using heavily coated electrodes justifies the small extra expense. We carry in stock a wide range of electrodes from $^5/_{32}$ inch to $^1/_4$ inch.

Set-Up Tables.—To facilitate welding, we provide a number of large heavy cast-iron tables having suitable bolt slots for set-up work and for clamping work preparatory to tacking. A number of lighter section tables are also available, which can be readily moved. These are used as supporting structures for jigs and fixtures. Tables are an indispensable facility for a properly constituted weldery. We also have several cast-iron floor plates set in concrete, which are used for setting up large structures.

Shears and Saws—Gas Cutting.—In the preparation of steel for welding, shears and power or friction saws are required. Heavy sections unsuited for mechanical cutting are shaped with a gas torch. Even with light sections a torch is necessary where contours vary from a straight line. In addition to the required number of hand torches, it is desirable to have one or more mechanically operated gas cutting machines. The fixed type with pantograph motion and the two-directional travel carriage type are equally serviceable. In addition, at least one portable gas cutting machine to operate on a

portable rail for straight line cutting, or on a radius arm for circle cutting, is of great service.

When a large number of gas cut parts is to be made, multiple cutting torches can profitably be used on mechanically operated machines, thus materially reducing the labor cost per piece. Figure 1 illustrates the use of multiple torches.

Positioning Machines.—Today, no properly constituted weldery can afford to be without positioning machines. The larger machines, for large and heavy work, should be power operated. The smaller sizes may be hand operated. Figure 2 illustrates a large type positioning machine designed and built in the author's plant.

A structure, once fastened to a positioning machine, can be quickly revolved into proper position for welding, thus eliminating the delays incident to desired setting with the use of a crane. In addition, "fast" electrodes can be used without danger of undercutting, and symmetrical fillets can be obtained. Savings in welding time of from 10 to 30% are regularly effected, and overhead cranes—no shop has enough of them in busy periods—are released for other work.

Bending Rolls.—The shaping of cylindrical and conical structures is usually performed on power-driven bending rolls. We have, however, found a bending brake more advantageous for conical work, if the cone is composed of two or more longitudinal plates.

Our bending rolls are not heavy enough for some of the work we produce, and often it is necessary to have plates rolled in plants hundreds of miles away. We sometimes order plate from the mill, rolled to size before shipment to us.

Rollers, Spiders and Clamps.—The use of rollers is advised for welding large cylindrical work. In Fig. 3 is shown an 11 foot 8 inch diameter water-cooled shell mounted on supporting rollers. Longitudinal and circumferential seams may both be welded in one setting, without continuous overhead crane service. Roller supports such as shown are low in cost as they consist only of channels tied together with plates and the necessary bushed rollers and supporting pins.

Two other methods for maintaining alignment of cylindrical and conical sections are used. In one case a spider with adjusting screws rounds the cylinder and maintains the true size during welding of the longitudinal seams. In another, adjusting straps and bolts are used to align the conical and cylindrical sections for welding.

Plate Brakes and Presses.—The extent to which proper tools for bending metal eliminate welding labor, is too little appreciated. Figure 4 shows a brake with a capacity of 13 feet 6 inches of $^1/_2$-inch plate (10 feet 6 inches between housings), bending a $^1/_2$ inch x 11 feet $2^1/_2$ inches plate into a channel shape. Two strokes of this press eliminate $22^1/_2$ feet of $^1/_2$-inch butt weld, which would be required if the design called for the welding of the detail with three plates. The saving in time and labor cost is obvious. Note that the brake is a completely welded structure.

Another type of power tool for bending material of heavier sections than can be handled on plate brakes is the hydraulic press. Not only is this tool useful in heavy work, but also on plate of lighter sections when bent edgewise.

Welding Fixtures.—Unfortunately, in most welderies there is too little realization of the importance of welding fixtures as aids in reducing labor. Much thought and study should be given to the design of suitable fixtures for aligning metal to be welded, both from the standpoint of interchangeability of parts, and of reduction of cost.

Fixtures should be of sturdy construction so as to prevent distortion due to localized welding heats, and should provide means for quickly setting and clamping the various parts of the structure. Figure 5 shows a striking example of an efficiently designed fixture. This fixture is designed so that it not only holds the various parts rigidly, but the lugs are held with spring steel snap rings which can be applied in but a few seconds. To position all these parts properly without a suitable fixture, would

Fig. 3—Rotating Rollers Permit Revolving of Cylindrical Work Without Constant Crane Service. This Naturally Results in More Continuous Welding and Lower Costs

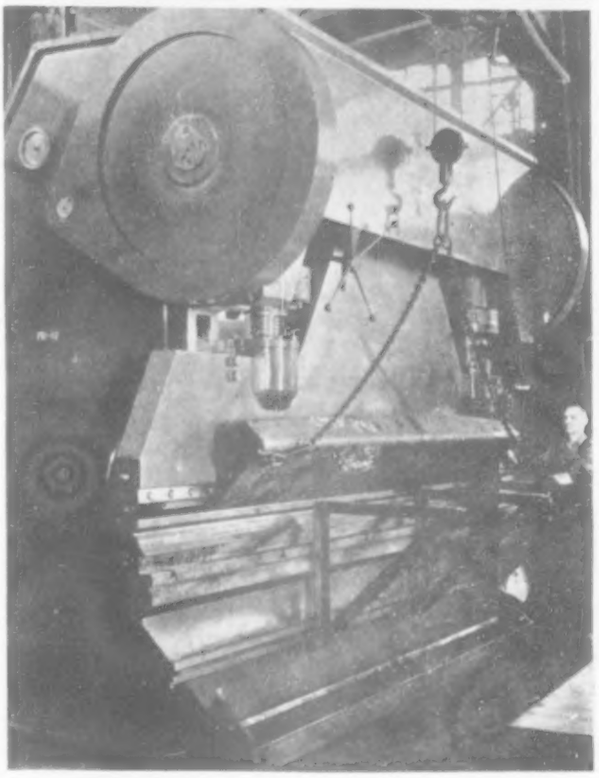


Fig. 4—There Is No More Profit Producing Tool in a Weldery Than a Plate Brake. One Stroke Eliminates 11 Ft. $2^1/_2$ Inches of Weld in the $^1/_2$-Inch Plate Being Shaped in This Photograph

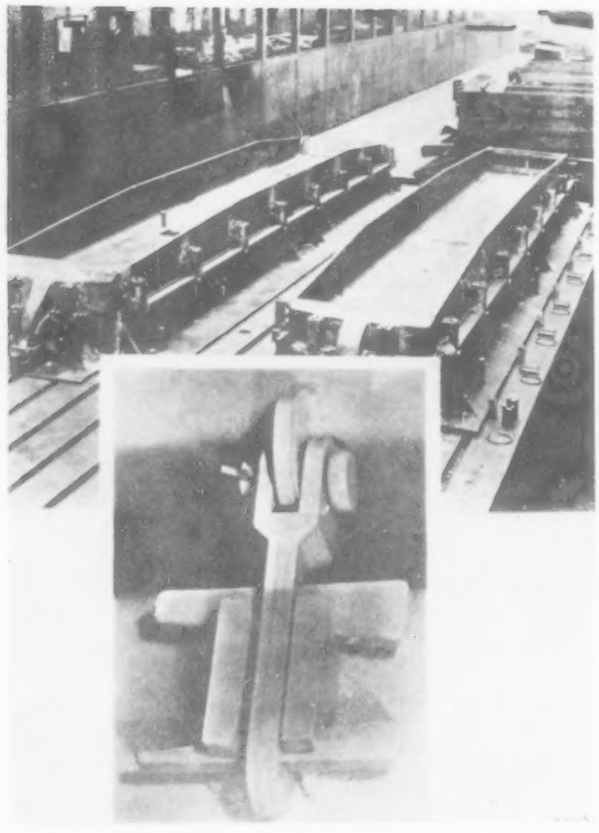


Fig. 5—Fixtures Are Indispensable for Production Work. These Two Align Forty-Three Separate Pieces and Make Possible Interchangeability and Low Cost. The Insert Shows the Two Taper Machined Lugs with Wedges Holding the Clevis in Position

be almost impossible. With it, the entire assembly of 43 separate parts is made in less than 10 minutes.

Heat-Treating Furnaces.—There are certain classifications of work which demand special facilities and equipment which are unnecessary in other lines. If the main product of a weldery is class one pressure vessels, facilities for thermal stress relief and heat treatment are essential. Every weldery has occasion to thermally stress relieve some portion of its products.

For heat treatment, a suitable furnace, either gas or oil fired, is needed. In almost all industrial localities, heat-treating equipment is available as a commercial service to the trade, and if the quantity of work to be heat-treated is not large, it may be best to depend upon other companies to do the work. We find that two oil-fired furnaces, required for our forging and flanging work, are a great advantage to us in heat treating certain of our welded products. At times we have much larger pieces to stress relieve than our furnaces will accommodate, and we send this work to a commercial heat-treating company or to one of the large steel foundries in our district. For best results, the furnace should be equipped with a thermostat to control the temperature.

With some large weldments, where grain refinement is desired, the heat treatment is done in pit annealers.

Testing Equipment.—Investigation and research have become necessary functions of a successful weldery. Whether a shop employs one or one hundred welders, it is important to know the quality of an operator's work. To qualify a welder for code work, necessitates the use of a testing machine for determining the ultimate and yield points. The investment required to enable a weldery to do its own tensile testing would not be justified in a small shop, as testing laboratories are available whose charges are moderate. In large organizations, and particularly those where other tests are regularly called for, the cost of a tensile testing machine can be justified.

When research work is carried on, and a research department is maintained, other equipment such as fatigue impact and hardness testing machines, is used. Then, too, metallurgy has become so generally recognized as a science of importance to welding, that microscopes for study of grain structures have become a necessity.

Machining.—While machining facilities are not essential to a weldery, and many successful ones operate without machine tools, there is a great commercial advantage in being able not only to fabricate welded equipment, but to machine it. There are many instances in which a complicated structure may be handled best by building it in sections and machining certain parts before total assembly and complete welding. Details which require bosses made from rolled steel bars are generally much cheaper in finished cost when the bosses are cut off in lathes and rough bored in the same setting. In other cases, satisfactory results and lowered costs are made possible by doing the necessary machining before welding.

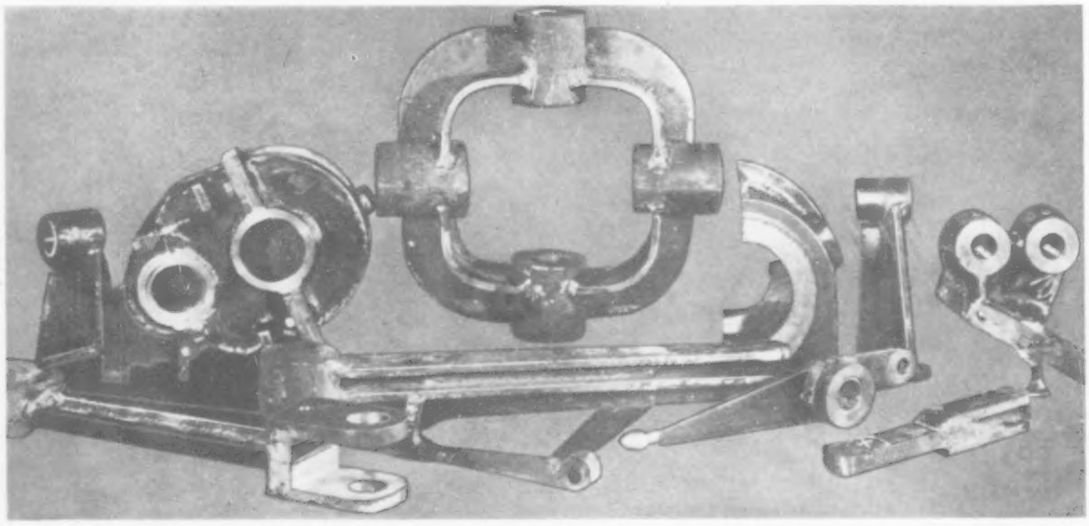


Fig. 6—Welding Will Increase at Least 50% When Engineers Learn the Potential Savings Possible in the Fabrication of Small Welded Parts

Fig. 7—This Photograph Strikingly Illustrates the Commercial Advantage of Welded Design in Small Parts. The Saving of 21% by Welding Is of Least Importance; the Complete Elimination of Service Failures Is of Greater Moment

Cost of Equipment.—Since the average weldery has been developed as an addition to a previously organized metal fabricating company, a complete analysis of capital equipment will not be attempted. Also there are many successfully operated welderies which purchase steel cut to order, or carry stock sizes which are prepared for use by gas cutting. It is possible to carry on extensive welding operations without saws, shears, tables, floor plates or other auxiliaries. The total capital investment is dependent upon the scope of work to be attempted and the capacity of the plant. The total cost of the following items of equipment is $25,205: arc welding machinery; 1/2 inch x 10 feet 6 inches (between housing) plate brake; pantograph mechanical gas cutting machine; two directional travel mechanical gas cutting machines; portable gas cutting machine; large power operated positioning machine; small hand operated positioning machine; hand gas cutting torch.

Engineering and Design.—In the organization of a commercial weldery, the next step is by far the most difficult, and upon it depends the success of welded fabrication; it is absolutely essential that competent designers and detailers be obtained. It is only through having the courage to depart from past experience and training that welded design can succeed. The writer has experienced instances in his company where attempts to redesign cast details for welding have failed nine times, but the tenth try resulted in a design highly successful, both from the standpoints of efficient operation and reduction in cost. The promises of revolutionary design in castings is remote, but with welding, the opportunities are unlimited. All that is needed to insure success is inspiration, imagination, creative thinking and the will to pioneer.

Many engineering companies overlook the large savings made possible by changing over small mechanical details from castings to welded construction. Too often these details are given scant consideration because of the small amount of money involved in each item, and attention is centered almost entirely on larger pieces. During the course of a year we produce thousands of small miscellaneous details in welding, and the cumulative saving is surprisingly large. Figure 6 shows a few small pieces of the type of details generally made of cast steel which we regularly make by welding. The tendency is simply to use the cast design drawing and change the construction to welding. This is almost always a mistake from a cost standpoint. Thought must be given to labor reduction through the use of rolled sections, and to straight line construction, which permits low cost in the preparation of the material for welding and of still greater importance, elimination of welding labor.

The three-piece gear reduction case, shown in Fig. 6 is an interesting example of the comparative costs of cast and welded small parts, because it would appear that such pieces would require so much labor to prepare the metal and to weld that they would not be cheaper than castings. The following is the cost comparison of the two methods of fabrication:

Steel Castings:					
Four sets of 3 pieces—388 lb.				$63.48	
Pattern:					
32 Hr.		@	$1.75	56.00	
47 Ft. Lumber		@	.10 ft.	4.70	
Total Cost of Castings					$124.18
Welded:					
Material	355 lb.	@	$ .03	$10.65	
Struc. Hr.	17	@	1.45	24.65	
Weld "	18	@	2.25	40.50	
Burn "	11	@	2.25	24.75	
Total Welded Cost					$100.55
Saving in favor of welding					$ 23.63
% Saving					19%

Fig. 8—The Evolution of a Sheave Bracket Is Shown in This Photograph. Originally in Cast Iron. Failures in Service Forced It Into Cast Steel. The Center Picture Shows the First Welded Design Which Did Not Prove Profitable from a Cost Standpoint
The Lower Bracket Is the Latest Development Which Cut the Cast Steel Cost 18%

Figure 7 shows a cast and a welded corner bracket produced in lots of 50 or more at a time. Without considering the cost of the pattern, the saving of the welded part over the cast design is 21%. This saving resulted from the use of a rolled angle and a plate with punched holes, which was bent to the required shape. The welding was thus reduced to a minimum and was done with the parts assembled in a fixture. The comparative shop costs of the cast and welded brackets are as follows:

Steel Casting 41 lb.			$5.95*
Welded:			
Shear	3.5 min.	$ .084	
Punch	1.4 "	.034	
Bend	4.0 "	.133	
Fitting	8.9 "	.214	
Gas Cut	11.0 "	2.745	
Weld	62.2 "		
Grind	7.4 "	.178	
		3.388	
Material		1.320	
Total Welded Cost			$4.71
Saving in favor of welded design			$1.24
% Saving			21%

* Pattern cost not considered.

In fabricating plants thousands of such parts can be found which lend themselves to welding with equally startling savings. Only lack of inspiration and thought on design prevents their transformation into the more economical welded construction.

The evolution of the counterweight sheave block shown in Fig. 8 is an interesting story in design. The one at the top of the photograph is a steel casting. It was originally made of cast iron, but high stresses and rough usage soon ended its career in that material. Our vigilance to cut cost corners sent the detail back to the engineering department for redesign in welding. The block in the center of the picture was the result, although there was no saving effected except the absorption of shop burden.

A more recent attempt at cost reduction, instigated by the welding shop, brought forth the detail shown at the bottom. The comparison of cost is enlightening.

Cast Steel: (Pattern development not included)		1260 lb.		$89.05
First Welded Design	530 lb.		$72.36	
C. I. Counterweight	425 lb.		19.00	
		955 lb.		91.36
Second Welded Design	525 lb.		$55.59	
C. I. Counterweight	350 lb.		17.40	
		875 lb.		72.99

An additional saving in the latest design is the elimination of the facing of the four bosses in machining.

As so often happens, once one becomes thoroughly welding-minded, one intuitively looks at details with a cost appraising eye. Comparing the two welded units, it will be seen that the bosses around the bored holes have been eliminated. This reduces the welding by six feet, and does away with the cost of the washers. The profile of the ends has been changed, simplifying the gas cutting, and reducing the material cost. In place of two heavy side plates in the first welded block, a light gage bent plate has been used to provide the oil pocket for the shafts—a further saving both in weight and labor.

One of the functions of an engineering department is to specify exactly the size and shape of every weld to be made. It is not the duty of a welding foreman or operator to guess the stress to be applied to any weldment. Therefore, a suitable method of designating welds should be adopted and used on every drawing sent to the shop for fabrication. Our Company has adopted the AMERICAN WELDING SOCIETY'S standard welding symbols. Copies of these are given to every draftsman and to the shop. Guess-work is eliminated, and each weld is made in accordance with the calculated weld strengths determined by our engineers.

Research and Investigation.—With the advent of the new low-alloy, high-strength steels and their advantages of high-tensile strength, high-elastic ratio, and resistance to abrasion or corrosion, the problems of design and welding fabrication become complex. For years, we had been disheartened by the costly failures of certain castings in clam shell buckets when these were subjected to severe tensile, bending and impact stresses. The constant increase of metal sections where failures occurred did not eliminate the breakage. The designs were such that in the castings planes of heavy metal were joined at right angles to lighter sections with heavy fillets at the angle. All the hazards of foundry practice were encountered in making these castings. The use of large dry sand cores prevented natural shrinkage of the cooling metal. Cracks developed in cooling. Shrinkage occurred, causing cavities which were hidden by the outer crust of metal. Segregations produced sections far weaker than the analysis of the heat would indicate. The result was failure in service, complaint from the customer, expense of replacement, and, of far more serious import to a manufacturer, a "black eye," making future sales to the customer extremely difficult.

We were welders, we had a creditable array of imposing low-carbon weldments to point to, and now we could obtain a new steel possessing 60,000 psi yield, 90,000 psi ultimate strength and over 20% elongation in eight inches. If we could redesign the faulty parts, build them by welding, using this steel, we felt certain the breakage would be overcome.

Our experience was so encouraging that we carried on an investigation of all the new low-alloy steels as they were brought out. As we became familiar with the technique of shaping, welding and heat treating of low-alloy steels, and as our engineers, striving to increase the strength of equipment and reduce its weight, learned the short cuts in fabrication cost, a wide and varied array of structures became an inviting field for welded high-strength steel.

A striking example of the advantage of the use of low-alloy steels is found in a recent proposal to an eastern railroad desiring coal loading equipment. The customer advised us that although our design was acceptable, the weight of three machines, built of low-carbon steel, was too great to permit their use on the existing pier which had been designed to carry lighter equipment. Our knowledge of the use of high strength steels, coupled with welded mechanical equipment, permitted a design incorporating a chromium, phosphorus, copper steel in heavy rolled sections, resulting in a weight reduction of 20%.

Cost Records.—The business wrecks strewing the road of America's industrial progress are more the fault of lack of knowledge of costs than any other single cause. Among medium and small-sized industries, the greater number still adhere to an antiquated method of estimating costs, by lumping all operations into one price

BURDEN STATEMENT

Welding and
DEPARTMENT D 11 Structural Shop PERIOD Nov. 1937 SHEET 1

	EXPENSE ITEM	THIS MONTH	LAST MONTH	YEAR TO DATE
	Indirect Pay Roll Expense			
3	Supervisory Direction	765.00	765.00	7848.84
4	Clerical Workers	282.00	284.00	2562.66
6	Inspectors			
7	Crane Men	1430.07	1385.97	10132.07
10	Indirect Labor	922.53	822.10	7755.19
	Gen. Maint. and Repair Expense			
11	Maintenance of Machinery and Equipment	189.81	213.91	2162.87
12	Amt. Jigs, Fixt. Dies, Patterns, Spec. Tools	1.82	97.54	634.81
13	Auxiliary Mach. Equipment not Classified	314.89	372.34	4097.85
14	Furniture and Fixtures			
15	Building Structures	54.68	83.94	648.09
16	Building Lighting Equipment	11.30		30.89
	Operating Supply Expense			
20	Small Tool Expense	803.01	841.39	981.84
21	Department Supplies	960.30	871.88	8708.78
22	Elec. Lamps, Fuses, Conduits	40.76	2.08	101.83
23	Coal, Coke, Charcoal	14.10	42.73	171.78
25	Fuel Oil	184.06	183.07	2036.82
26	Gas	11.73	14.75	190.82
28	Water	68.13	61.73	748.83
29	Oxy-Acetylene	402.82	675.39	5886.93
	Supervision Losses			
40	Defective Work Losses			.59
41	Idle Time Losses	20.66	3.42	1868.97
42	Excess Labor Charges	.51	1.38	11.60
50	Other Errors			
	Administrative Expense			
57	Traveling Expense			
58	Telephone and Telegraph			
61	Gen. Office Supplies			21.96
62	Printed Forms			165.36
70	Adm. Expense Items, Unclassified			128.75

Fig. 9—Monthly Burden Sheets Are Helpful in Keeping Expenses in Line

DATA SHEET

C. O. 1453
PROP. 6-24578-Tex.
EST. DATE 11-4-37
DATA SHEET ISSUED 10-15-37

CLIENT The - - - - - - - - - -Company

DESCRIPTION One 72" Valed Lathe

MATERIALS REQUIRED FOR One MACHINES

STRUCTURAL	WEIGHT	RATE	VALUE	LABOR HOURS
PLATES	11,722	2.80		Struct. 865
SHAPES	295	3.90		
BARS	3,175	3.25		Weld 270
RODS				
RIVETS				Purge 5
SHEET STEEL				Sand 60
FLOOR PLATE				
RIVETS				
WASTE				
WORK ALLOWANCE	530	3.00		
TOTAL STRUCTURAL	17,682			
MECHANICAL				
IRON CASTINGS	1,088	7.80		Mach. 675
STEEL CASTINGS	640	11.80		Floor 450
DROP FORGINGS	40	3.00		
OUTSIDE FORGINGS				Paint]
SAE 1112	92	4.00		Ship] 85
HOT ROLLED STEEL	860	3.50		
COLD ROLLED STEEL	1			
MISCELLANEOUS CASTINGS				
CARBOXY				
SAE 1020	300	3.80		
BOLTS AND NUTS	10	7.80		
PIPE				
STRUCTURAL OR STEEL				P & S Mat. 15.00
TOTAL MECHANICAL	2,750			
OUTSIDE PURCHASED				
Miscellaneous	107		25.00	
Stress Relieve & Sand Blast			700.00	
LOCAL FREIGHT			15.00	
DESTINATION FREIGHT TO FOB Our Works				
DRAWING 25 HRS.				
PATTERNS 63 HRS. 157 Ft.				
PATTERN LUMBER				

A THREATENED DEVIATION OF 5% FROM ANY OF THE ABOVE ALLOWANCES MUST BE REPORTED TO W. G. HILDEBRAN IMMEDIATELY UPON BEING DETECTED AND NO ORDER SHALL THEN BE ISSUED CALLING FOR MATERIALS OR LABOR IN EXCESS OF THAT ALLOWED UNLESS NEW CONSENT BE FIRST OBTAINED

Fig. 10—A Data Sheet, Carrying the Detailed Information on Weight and Cost of Materials, and Estimated Labor Hours, Should Guide in Purchasing and Production

group, and by keeping actual cost records, if they are kept at all, in the same manner. For instance, all labor, layout, shearing, gas cutting, bending, fitting-up, welding, cleaning and machining carry the same labor and burden rate. The fallacy of this procedure should be evident to any one who gives any consideration to the actual expense connected with these various operations. A layer-out, a fitter, a cleaner, work without the aid of power operated tools. Bending, gas cutting, welding, and machining operations are performed with equipment costing from a few hundred to many thousands of dollars. Some operations call for operators, who because of their high degree of skill, command high rates. Other operations can be performed by unskilled or semi-skilled men. Depreciation of equipment, taxes, floor space, power consumption, lubrication, small tools, supplies and many other incidental costs must be paid for. These go to make up legitimate charges which should be borne by the particular operation requiring them. To prorate these costs over all operations means that certain operations are sold at too low a cost, others too high. As an example, we purchased last year a plate bending brake, costing $8500. Dies and special equipment for it cost an additional $600. An electrically operated jib crane, at a cost of $500, was installed to service this tool. Valuable floor space, 20 ft. x 20 ft. was taken up, and the electric power to operate a 25 hp. motor is consumed. Our estimate of the actual cost of operating this tool, the labor and shop burden, is $2.00 per hour.

Now, let us take another classification of labor, the fitting of parts for welding. No machine tools are required, with the exception of an occasional heavy lift with a crane. The fitter works with a rule, a square, and a level, setting the component parts properly and clamping them together preparatory to tack welding. True, the fitter is a skilled mechanic, paid possibly ten cents an hour more than the brake operator, but he uses no costly equipment, little or no power, and much less floor space. Our analysis shows this operation costs in labor and burden $1.35 per hour. The average labor and burden rate for the entire department may be $1.60 per hour. Now, let us assume that we have to figure a particular job on which the bending and fitting operations take an equal amount of time, say two hours. Two hours bending and two hours fitting at $1.60 per hour is $6.40. The actual cost of these same hours is $6.70. The administration charge of 17½% of the labor and burden rate is $1.12 in one instance and $1.17 in the other. The total cost is therefore $7.52, using an average labor and burden, and $7.87 using the true labor and burden, a difference of 35 cents, or an actual loss with the average burden of 4.6%. This would reduce by nearly 50% the profit normally figured, and in times of keen competition, would completely eliminate the profit. The seriousness of this situation is that the company actually believes the job is profitable, and it is only when the profit and loss statement is made—and with many small companies this occurs only at the end of the fiscal year—that the management finds the supposed profits do not exist.

Furthermore, in periods of keen competition, the flat rate basis of estimating often results in loss of orders which would be obtained if correctly figured. Our company has established labor and burden rates covering all operations.

Once a month the Accounting Department tabulates an actual burden cost for each department. The ex-

pense is broken up into many classifications, and the burden sheet carries the comparison with the previous month and the total for the year to date. The works management has before it complete information on burden costs. If the cost of any one item for any one month is high, a comparison with costs for previous months quickly show the reason, and steps for correction can be taken. Information on any particular detail of the burden is readily available to a shop department head. A typical burden sheet is shown in Fig. 9.

Little work is obtained today without firm quotations. Therefore, when an order is received, the estimate upon which the work was priced is available. When the work order is sent to the shop, a data sheet accompanies it, listing the material required and the labor hours originally estimated (see Fig. 10). Without this information, particularly the labor estimate, the shop would work completely in the dark. Every foreman should have the labor estimate available and be held accountable for producing the work within the hours figured. Daily records of consumed hours should be kept and be available so that the shop management may know at all times by comparison of the consumed hours with the estimate, just how the work is progressing. Some such method of labor control is essential for efficient management. In our company the detail record-keeping is not duplicated in the shop and office. The cost accounting department is not concerned with keeping a record of the labor details entering into the costs. Only summaries are kept in the office for compiling total costs. If detailed information concerning any operation is desired, it may be obtained from the shop office. Our shop labor records are kept by one individual for the structural and welding shop, which normally employs about 100 men. The expense of record-keeping is small and unimportant in comparison with the results obtained by holding the shop management responsible for results.

Publicity and Sales Promotion.—Our employees who contact the trade are engineers. They are familiar with our production facilities and are firmly welding-minded. This has prompted them to suggest to customers that better, stronger and cheaper details may be made by substituting welded parts for those designed as castings. In many instances these sales engineers either make free-hand sketches during their calls, or bring the customer's drawings to our drafting room for redesign in welding before submitting prices on the work.

In addition to the personal contacts of our sales engineers, we advertise widely in trade magazines, by letters, a twelve page yearly calendar, and monthly blotters broadcast to the trade showing our achievements in engineering and production. We furnish copy and photographs of welded equipment for national advertising by steel companies, and to manufacturers of welding equipment and supplies.

Realizing the direct advantage to us in orders through the advancement of welding, we have presented illustrated lectures before engineering societies and technical schools from the Atlantic Ocean to the Mississippi River Valley, and from Toronto to New Orleans.

In addition to these efforts to promote the science and art of welding, we have written and published in technical and trade journals, scores of articles on various phases of welding, including research, design and fabrication. Most of the material presented represented original work done in the particular field. We hope that this has played some part in acquainting the engineer, the fabricator and the purchaser with the advantages of welded construction. Our plant, as are those of most modern welderies, is open to our customers and to our competitors. We believe that whatever benefits the welding art, and speeds the day of its universal adoption, will benefit us.

Conclusion.—One cannot review the industrial progress of the past few years without realizing that no factor has contributed more to that progress than welding. Our national wealth has grown as our industrial developments have made possible lower costs and a wider distribution of commodities. American incentive, ingenuity, and ceaseless effort have in the past borne fruit. Mechanized farming, mechanized industry, mechanized distribution are the only means of creating greater wealth.

What part will welding play in this program? The answer to that question can be found by looking at the record of the recent past. Today, our unmatched distribution of automobiles is the envy of the world. Without welding, the modern automobile could not be made. Our distribution of household labor-saving appliances is unparalleled. Estimate the cost of an electric refrigerator built without the welding art. In transportation, the electric locomotive, the light-weight diesel engine, the high-speed train, and the modern ship have been made possible through welding. Increasingly, our bulk handling machinery, our bridges, our machine tools, our buildings, and furniture, have been built with the electric arc. This progress has resulted only because through welding can this stronger, lighter, more efficient equipment be built at lower cost.

With this background, can any engineer, any industrialist, yes, even any layman question the importance of the welding art in the material progress of our people? This is a challenge to the commercial weldery. Will it accept that challenge?

In this analysis of a commercial weldery, we have endeavored to point out the fundamental principles upon which success is built: management, design, production technique and research. We have said much about reduction of cost through reduction of labor. That is the basis upon which progress is built and a basis which the builders of welding equipment and supplies endorse one hundred per cent.

There is every promise of the commercial weldery contributing its full share toward future national prosperity.

1938 BOUND VOLUME

Bound Volumes of the JOURNAL of the Society for the year 1938 will be available shortly with imitation black leather covers. Contains a wealth of information on the latest developments in welding. Also contains Subject and Authors' Index. Price, $5.00 plus postage to members; $6.50 to non-members.

TUNGSTEN CARBIDE in HARD Surfacing Oil Well Bits*

By NOLAN J. CLARK†

THREE miles straight down on a slender stem of steel is a small unit grinding away in unkown regions. Unknown—no, not quite that, because very often some one has gone to the trouble and expense to pull to the surface a two or three inch diameter cylinder of the strata at that depth which enables one to determine something of the conditions under which this small unit, a rock bit, is operating.

From the core mentioned above we know that this unit must penetrate material varying widely in physical properties. Quartz, limestone, sandstone, pyrites and gypsum are some of the rocks and minerals encountered, as well as complex ore bodies.

The development of bits to cut these formations makes a very interesting story. However, only a short description can be given here. Churn type drills were used in the first oil fields in the East. With the increasing demand for petroleum the rotary drill was developed with a fish tail bit made from forged steel, and from this was evolved the modern rock bit used on a similar drill stem. At present practically all oil prospecting is done with rotary drilling tools. The softer formations—

Fig. 1—Rock Bit Cutters Showing Location of Welded Tungsten Carbide on the Faces of the Teeth

Before After

Fig. 2—Fish Tail Bits Illustrating the Fingering Action of Tungsten Carbide Inserts When Drilling

clay, shale and some soft rock can be cut to advantage with fish tail bits but harder formations require bits which do not take so much shock and will stand higher pressures than the fish tail. To meet this demand, the rotary rock bit has been developed.

This bit, making use of the same scraping action as the fish tail, combines other actions which permit the cutting edges to be multiplied by a number of teeth on a cylindrical or tapered cutter. This cutter is free to turn on its axis and therby relieves to some extent the strain that each cutting edge is called upon to bear.

At the same time the teeth are pressed down in the formation, resulting in high abrasion of the cutting surfaces of each bit. This abrasive action calls for the hardest of materials to withstand the attack. The first roller type bits were made of carburized steel, representing, as it did, the maximum hardness for steels backed up with a soft core for toughness. This combination of properties, i. e., maximum hardness or abrasion resistance and maximum toughness, are two properties difficult to accomplish at the same time in steel. Carburized steel to some extent met these problems but research has developed harder and more abrasion resisting materials.

Welding presented a method of increasing the wear resistance of surfaces and a number of combinations of alloys were used over a period of time. Manganese, Chromium, Molybdenum, Cobalt and Tungsten were favorite alloying elements for these surfacing materials.

* Abstracted from "Foote-Prints."

† Asst. Chief Metallurgist, Reed Roller Bit Co.

Carbides, Borides and Nitrides all offered some promise. Difficulty was experienced in making welded surfaces of most of these alloys that would have uniform properties.

Work done in European countries and finally in this country led to the development of cemented tungsten carbides bonded by a tough material such as Cobalt. This indicated the possibility of using the hard, brittle carbide of Tungsten in a tough binder which would have some of the properties of each. The process of making these cemented carbides is very expensive and their attachment to cutting tools can be accomplished only by brazing. For these reasons their use in oil well tools has been quite limited.

Ultimately fine grain tungsten carbide powder was applied directly to the cutting surfaces of bits. This was first accomplished by puddling-up the base metal of the bit with a carbon arc so that it surrounded the tungsten carbide particles, thus producing a surface containing a large number of small particles of tungsten carbide. A number of other methods have been developed for accomplishing the same result. It has been found by judicious additions to the steel and regulating the methods of heating that the over-all properties of the hard-face overlay may be controlled to a certain extent. Tungsten carbide of various grain sizes can now be applied by either electric or torch methods of welding. In all cases the overlay consists of a matrix of some ferrous alloys either sweated-up from the base metal or added in the form of a thin wall tube, which filled with the carbide particles is melted down around the grains.

Tungsten carbide is made from tungsten powder and carbon in an electric furnace and consists of a mixture of several carbides of tungsten. Economical methods of making it have been developed which yield a fine grain metal that has a maximum of ductility. The cast button is crushed to the screen size best suited for the purpose and results in sharp-edged, irregular grains. The steel binder used to cement the grains to the base metal, alloys with the carbide to such an extent that a strong bond results.

By the above methods tungsten carbide can be applied to all of the surfaces of rock bits used for drilling hard formations. Even the old fish tail bit has been rebuilt to take tungsten carbide. The same granular carbides find a great use on the faces of these bits and a certain reinforcing of the cutting edge is accomplished by inserted tungsten carbide "fingers" extending downward from the cutting edge. The effect of these on drilling can be clearly seen in the fingering wear shown in Fig. 2. The cuttings made by all bits in the rotary class are removed from the hole by forcing an aqueous fluid down the hollow drill stem and up the outside between the drill stem and the wall of the hole. This fluid carries a great amount of slush which is often quite abrasive. Tungsten carbide and alloys containing them have been used to advantage where this slush causes severe wear in restricted areas such as the slush tubes in bits.

It is possible to cast tungsten carbide in tubes or liners of a wide variety of shapes. Many of these special shapes are made from tungsten carbides that have some metal such as Cobalt added for the purpose of decreasing their brittleness. This, however, lowers the over-all hardness.

French Specifications for Qualifying Welders*

THE PRESENT specifications replace an analogous set issued in 1936. The objects of the new Specifications are:

1. To outline the fields of specialization in gas and arc welding corresponding to particular or different applications, and to state the professional knowledge and qualifications required of welders called upon for such work.

2. To establish qualification tests for welders in each special field and to indicate methods of interpreting the tests.

3. To create a "Certificate of a Specialized Welder" for each specialized field and to determine on what basis the Certificate should be granted and renewed.

The Certificates are intended to contribute to the high quality of welded construction and to improve conditions of employment by providing personnel qualified in each special field. They also meet conditions imposed by other Rules and Regulations in force. Those holding the Certificate of Professional Aptitude in Gas and Arc Welding are not exempt from the tests in the present specifications if they desire to enter a specialized field.

The following classification of special fields has been adopted:

A. Gas Welding (oxyacetylene)

1. Oxyacetylene welding of boilers and pressure vessels.
2. Oxyacetylene welding of pressure piping (*a*) thicknesses up to 0.020 inch, butt and angle welds, (*b*) thicknesses up to 0.020 inch, lap welds, (*c*) all thicknesses.
3. Oxyacetylene welding of aircraft steel (mild and Cr-Mo steels).
4. Oxyacetylene welding of special metals and light alloys in aircraft construction (aluminum and its alloys, magnesium and its alloys, and 18-8).
5. Oxyacetylene welding of ordinary tank steel.
6. Oxyacetylene welding of domestic heating piping and the like.
7. Oxyacetylene welding of steel in industrial sheet metal work, ventilation, vehicles, etc.
8. Oxyacetylene welding of steel in general structural work.
9. Oxyacetylene welding of special and non-ferrous metals in various constructional work.
10. Oxyacetylene welding for general repair and maintenance.
11. Oxyacetylene welding of copper.
12. Oxyacetylene welding of aluminum.
13. Oxyacetylene welding of lead.

* Abstract of "Specifications de l'Institut de Soudure Autogène relatives à la qualification des Soudeurs au chalumeau et à l'arc, et à l'attribution de certificats de soudeurs specialisés," published in *Revue de la Soudure Autogene*, **30**, no. 293, pp. 462–479, August 1938.

B. Arc Welding

1. Arc welding of boilers and pressure vessels.
2. Arc welding of pressure piping ((*a*) thicknesses up to 0.20-inch butt and angle welds, (*b*) thicknesses up to 0.20 inch, lap welds, (*c*) all thicknesses, butt welds, (*d*) all thicknesses, lap welds).
3. Arc welding of ordinary tank steel.
4. Arc welding in the construction of bridges and buildings.
5. Arc welding of steel structures ((*a*) light structures, (*b*) heavy structures).

C. Atomic Hydrogen Welding

These specialized fields are subject to change in the future in accordance with technical progress.

Practical Tests

Practical tests, which, however, are not fixed arbitrarily, have been formulated for each special field. The tests correspond faithfully with the operating difficulties the welder must encounter. Base metal for the tests must be of recognized weldability and filler metal must meet standard specifications. The welder is supplied with suitable apparatus. He selects his own tip and diameter of filler rod. The time allowed for the test is up to three times the period considered normal in industrial welding, in order not to disqualify a nervous welder. Although the usual tension and impact tests are not specified in judging the results of the tests, since they are not a simple means of revealing defective execution, these customary mechanical tests may be included, if necessary.

Certificate of Specialized Welder

The term "specialized" is used in the purely technical sense that the welder is proficient in a particular type of welding. The certificate is temporary, its term of validity being clearly indicated, but it may be renewed. Renewal may require retest, if the Institute considers it necessary. Candidates must be at least 18 years old or hold a Certificate of Professional Aptitude in Gas and Arc Welding. Preferably the applicant for a Certificate of Specialized Welder should try the tests by himself before applying to the Institute for formal examination. If he sends the results of such preliminary tests to the Institute they will notify the applicant of his rating, which will not, however, affect his formal certificate tests. The formal tests are free of charge at the Institute's headquarters or at agencies delegated by the Institute. A nominal fee of 50 francs is charged for the certificate.

Discussing the tests for arc welding of steel structures, it is emphasized that the usual tests based solely on strength or ductility may accept decidedly low-grade welds made with high-strength electrodes yet reject welds of average quality made with ordinary electrodes. Furthermore, the customary tests, such as the tension test, fail to reveal adequately poor penetration and slag inclusions. Consequently, welders are certified either for light or heavy structural welding. The tests do not include any measurements of strength and ductility. Merely the geometrical defects of execution are revealed for several typical difficulties regularly encountered in practice. Contrary to an erroneous belief, the difficulties are of equal magnitude in light and heavy structural welding. The heavy structural welds may be inspected by macroscopic etching of a cross section, but preferably by milling the weld with a 90° conical miller, about $1^1/_8$ inches diameter, which is rapid, simple and searching on account of the obliquity of the cut.

Test for Light Structural Welding

Structural steel: tensile strength = 60,000 lb /in.²

(*a*) Shop welders—specimens are flat and can be turned over.
(*b*) Field welders—1 series with plates fixed vertically; 1 series with plates fixed in a flat position (specimens 1 and 2 welded flat and overhead, specimens 3 and 4 welded entirely overhead).

Test	Work to Be Done	Time Allowed for Welding	Tests to Be Performed on the Welded Joint
1	Deposit fillet weld (0.12-inch leg) as in Fig. 1 joining two plates 2.0 x 0.24 inch, to two angles 1.18 x 1.18 x 0.12 inch.	15 minutes	Pull apart in tension. Throat of weld must be 0.06 to 0.10 inch.
2	Deposit fillet weld (0.16-inch leg) as in Fig. 1 joining two plates 3.2 x 0.47 inch to two angles 2.0 x 2.0 x 0.20 inch.	20 minutes	Pull apart in tension. Throat of weld must be 0.10 to 0.14 inch.
3	Fillet weld (0.04-inch leg) round bar 0.79 inch diameter to plate 0.16 inch thick, Fig. 2.	10 minutes	Break in the weld by bending in a vise. Throat of weld must be 0.10 to 0.14 inch.
4	Fillet weld (0.08-inch leg) two plates 0.12 inch thick to a plate 0.06 inch thick, Fig. 3, the plates being tacked 1.18 inches apart. Weld only on the inside faces.	20 minutes	Break in the weld by bending in a vise. Throat of weld must be 0.04 to 0.08 inch.

NOTE: There must be no undercut. Fractures must show perfect penetration without inclusions, blow-holes or imperfections of any kind.

Test for Heavy Structural Welding

Structural Steel: tensile strength 60,000 to 77,000 lb. /in.²

(*a*) Shop welders—specimens are flat but only specimen 1 may be turned over.
(*b*) Field welders—1 series with plates fixed vertically; 1 series with plates fixed flat and welded overhead.

Test	Work to Be Done	Time Allowed for Welding	Tests to Be Performed on the Welded Joint
1	Butt weld in two unscarfed plates, 2 x 8 x 0.39 inch thick.	25 minutes	Mill out 4 holes with portable miller, polish and etch macroscopically, then break weld by bending.
2	Butt weld (70° V) without reverse welding in two plates 2 x 8 x 0.59 inch thick.	40 minutes	Mill out 4 holes with portable miller, polish and etch macroscopically, then break weld by bending.
3	Weld two plates 2 x 4 x 0.59 inch thick as in Fig. 4, throat of weld to be 0.59 inch. Reverse welding not allowed.	40 minutes	Ditto. Throat must be 0.59 to 0.71 inch.
4	Fillet weld (0.20-inch leg) three plates 0.32 inch thick, Fig. 5, two plates to be tacked 1.18 inches apart before the test. Weld only the interior angles.	30 minutes	Break in the weld by bending in a vise. Throat must be 0.14 to 0.18 inch.

NOTE: The inspector may choose any place in the weld for milling. There must be no undercut. The milled surfaces and the fractures must reveal perfect penetration without inclusions, blow-holes, or imperfections of any kind.

Test for Oxyacetylene Welding Pressure Piping

(*c*) All thicknesses.

Specimens are weldable mild steel 4 x 12 in.

Test	Work to Be Done	Time Allowed for Welding	Test to Be Performed on the Welded Joint
1	Two pass, inclined, butt weld in two plates 0.39 inch thick.	25 minutes	Bend along weld, the root of the weld in tension. Distance between supports = 5 *t* (*t* = thickness). Must withstand 90° bend without cracks.
2	Two-pass vertical butt weld (one layer advancing a little ahead of the other) in two plates 0.39 inch thick.	30 minutes	Ditto.
3	Angle weld in two plates 0.39 inch thick.	30 minutes	Ditto.
4	Overhead weld in two plates 0.39 inch thick.	40 minutes	Ditto.
5	Right angle fillet weld in two plates 0.39 inch thick in downhand position.	30 minutes	Bend the vertical plate. Fracture must show no blow holes or inclusions.
6	Overhead right angle fillet weld in two plates 0.39 inch thick.	40 minutes	Ditto.

SIMPLIFICATION OF MACHINERY

Manufacture by Use of Electric Arc Welding*

By JOHN THOMSON†

THERE are many parts of standard machines, where large numbers of similar parts are required, which may with advantage, as regards both economy and utility, be made of weldings instead of castings. The advantages are much greater, however, where a machine has to be made on short notice for a special job, and where only one of each part may be required. In such cases stock material may often be utilized for the weldings, resulting—especially in the present congested state of the foundry trade—in the machine being completed in a small fraction of the time required to make the machine with castings. This reduction in the time required to obtain the raw material, together with an important saving in time and cost due to the elimination of pattern-making and also the scope provided by weldings for the simplification of the machining of parts, have enabled us to make several machines for special work which would otherwise have been impossible. I propose describing the design and manufacture of one such machine which was successfully put into operation at the end of last year.

One of our standard products is a Tower Crane used in shipyards. Figure 1 shows one of these cranes with an Atlantic liner in the background. These cranes consist essentially of a fixed tower structure with a rotating mast and jib. The rotating portion is supported on a footstep bearing at the bottom of the mast and it is guided at the top with rollers which contact with a vertical path about 14 feet diameter. This path is incorporated in the platform structure at the top of the tower. The platform has an external diameter of nearly 20 feet and as it is necessary to machine the path after it has been riveted to the completed platform structure, a lathe or boring mill was required which would accommodate work up to 20 feet diameter.

In May of 1937 we had on hand orders for eight of these cranes for a naval dockyard and as the boring mill which had previously machined the paths was fully occupied with work of national importance for two years ahead, we had to consider some alternative method of carrying out this work.

We got in touch with the Machine Tool Makers Association and all they could offer us was their standard vertical boring mill of 20 feet capacity. Their price for such a machine was £12,000 ($58,320), and the time for delivery was 2½ years.

The work in prospect did not warrant this expenditure and the delivery made the proposition useless for our purpose. We pressed them to consider a simpler machine which would machine the paths without being

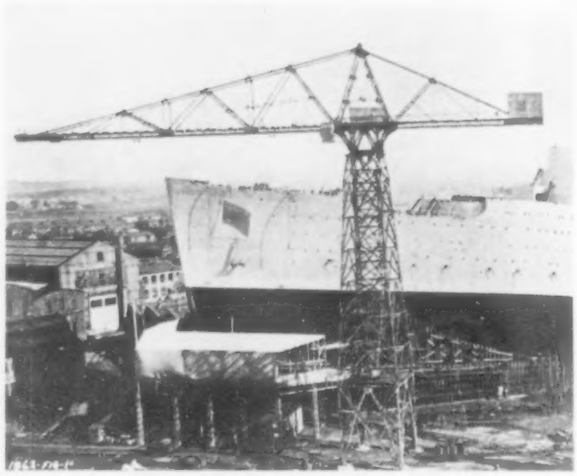


Fig. 1—A Tower Crane Used in Shipyards

capable of doing the general work expected of a vertical boring mill, but they informed us that they had not the staff available to design such a machine and that the delivery could not, even with such a machine, be less than two years. They gave a rough indication of the price as £3000 ($14,580).

These were the circumstances which led us at the end of July 1937 to the decision to design and make in our own works an all-welded machine. The results very much exceeded our expectations as regards costs, date of completion and the efficiency of the machine. We were actually machining a path in nine weeks after the design of the welded machine was started in the drawing office, and the number of hours taken to machine a path compared favorably with that taken previously by the standard boring mill. The finish of the machined surface was also equally good.

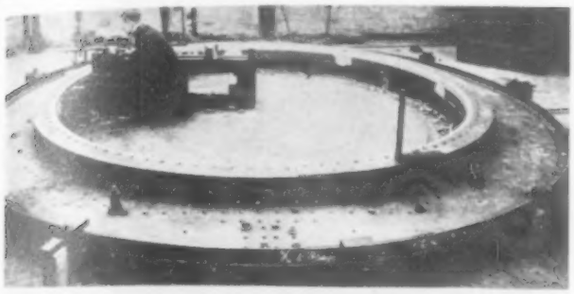
The ascertained cost of this machine was £770 ($3745.20), and details are given in Table 1.

In view of the low cost of the welded machine as compared with the indication of costs which we had received from the Machine Tool Association we decided to send an inquiry for a machine to one of the largest non-associated firms. The reply quoted a price of £2500 ($12,150), and as this did not include electrics and foundations we should add say £150 ($729), making the total cost £2650 ($12,879). This price included an overhead bridge which was essential for the machine they had in mind, but was not essential for the welded design. The bridge does, however, make the machine of more general utility and we have a welded bridge at present in hand. The estimated cost of this bridge is £300 ($1458), and

* The author of this paper received the first award, $712.28, in the Metal Cutting division of the Functional Machinery classification of the $200,000 Program sponsored by the James F. Lincoln Arc Welding Foundation, Cleveland, Ohio. (Abstract.)

† Works Director, Sir Wm. Arrol and Co., Ltd., Bridgeton, Glasgow, S. E. Scotland.

Fig. 2—Work Bolted to Radial Beams, with Toolholder Bolted to Table



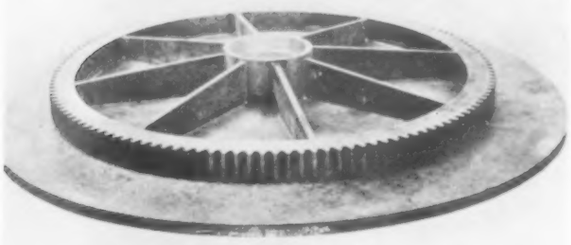


Fig. 3—The Complete Table Unit

Table 1—Ascertained Costs of Arc-Welded Rotary Planing Machine

Steel plates, sections, billets, etc.	£141	12	0d	$ 688.26*
Forgings	7	18	5d	38.62
Cast iron slipper pads	3	5	2d	15.87
10 inch worm reduction gear	34	2	6d	165.86
Ball bearing	12	14	6d	61.94
Cast iron stepped cone pulley	14	12	4d	71.12
Gear cutting of rack pinions, etc.	27	7	2d	133.01
Electric motor starters, etc.	61	5	7d	297.85
Miscellaneous material	26	3	3d	127.17
Foundation work including wages, material, cartage, etc.	114	10	6d	556.66
Drawing office wages	32	12	6d	158.64
Shop wages in fabrication, machining and erection	130	15	9d	635.73
Establishment charges	163	9	8d	794.59
Total	£770	9	7d	$3745.32

* Pound taken at par value of $4.86; shilling at $0.25; and pence at 2¢.

when this is added we will have, at a total cost of £1070 ($5200.20), a machine more convenient for our purpose and capable of doing any work at least equally well as the machine submitted to us at a cost of £2650 ($12,879), and it was finished—so far at least as was necessary to machine the paths—in nine weeks compared with the eighteen months required by the tool makers. Excerpts from the shop progress report relating to this machine are given in Table 2.

The machine consists essentially of a table rotating in a horizontal plane about one inch above the floor level. The driving power was provided by a 25 hp. electric motor working through reduction gears to a rack welded to the underside of the table. On the floor surrounding the table, plate radial beams were grouted into the concrete. When machining the paths the work was bolted to these radial beams and the tool holder was bolted to, and rotated with, the table, as shown in Fig. 2. From this it will be seen that the outside dimensions of the work were limited only by the floor space, while the internal diameter to be machined was limited only by the length which the tool holder can safely overhang the

Table 2—Excerpts from Shop Progress Report Relating to Arc-Welded Rotary Planing Machine

30th July	1937	Drawings started
6th Aug.	"	First drawing issued and table plate ordered from rolling mills
13th "	"	All drawings issued except foundation plan. Table plate delivered and electrical gear ordered
20th "	"	Foundation drawings issued and foundations started. Table plate cut to shape and flattened. Small material being cut to shape
27th "	"	Upper slipper path welded and being machined. To be sent for gear cutting on 30th instant
3rd Sept.	"	Bevel wheel and pinions machined and sent to gear cutters
10th "	"	All gear cutting completed. Slipper path being fitted to table unit. Brackets being welded
17th "	"	Foundations completed and lower slipper path with radial beams grouted in
24th "	"	Complete table unit welded and upper slipper path fine-machined on working face. All electrical gear delivered
1st Oct.	"	Machine completed, and first job being machined

table. For machining the external surfaces of smaller work the job is fixed to and rotates with the table, while the tool box is fixed to the radial arms on the floor. In the machines submitted to us by the machine tool makers the table was about 3 feet above the floor level, and as the work had always to be fixed to the rotating table and the tools always fixed to the bridge, the outside dimension of the work was limited by the distance between the bridge uprights.

One important feature of the welded design is that the whole machine is at or below floor level and when the machine is not in use the floor is available for assembly work. This was in our case an important consideration. When the overhead bridge is completed it will be made movable as there are many jobs which can be done more efficiently without it and the floor can still be cleared for other work.

The table consists of a rolled plate, 10 feet diameter and 2 inches thick, to which is welded the slipper path and also the housing for the center ball bearing. The outside face of the slipper path is gear-cut to form the rack for rotating the table. The slipper path and center housing are connected with radial arms which also serve to stiffen the table plate. The lower slipper path is grouted in concrete after being machined on the top surface, and cast-iron packings are bolted to this path and carefully trued up by hand scraping. The lubrication of the sliding face is provided by rollers running in oil recesses in these cast-iron packings. The electric motor was fitted with cone pulleys to allow the speed of the table to be varied to suit the diameter of the work being machined. The first reduction consists of a standard enclosed worm gear reducer which was purchased. The second reduction, which also changes the direction of the drive, consists of a bevel pinion gearing into a bevel wheel. The third reduction is formed of the steel pinion gearing into the rack billet. The two pinions are cut from solid forged bars, but the bevel wheel and all brackets supporting the gearing were of welded design.

FABRICATION

The rotating table was cut to its circular shape by torch burning after which it was carefully flattened in a hydraulic press. The upper slipper path was formed of

rolled square billets bent into two semi-circles and the end welded together to form a circle. Full strength welds to connect the two halves together were not necessary as the subsequent welding of the path to the table plate was adequate to transmit the driving load on the teeth. The welds were consequently small, the purpose of the weld being to hold the parts rigidly together during subsequent machining and gear-cutting. After welding, the ring was machined on all faces and the teeth forming the rack were cut on the outside face.

The cylindrical housing for the ball bearing was formed of a rolled steel plate 2 inches thick, bent in a hydraulic press to cylindrical form and the longitudinal joint welded. All faces of the cylinder were then rough machined. The radial stiffening plates were cut to shape by torch. In assembling the table unit, the ball bearing housing was first welded central on the table plate, after which the radial stiffening plates were welded in position. This assembly was then put in a lathe and the outer ends of the radial plates were machined to the exact diameter of the inside of the slipper track ring. At the same setting, the table plate was machined in the way of the slipper path so as to give it a true seating. This machining was considered advisable as it was essential that there should be no distortion in the rack teeth when the slipper path was welded in position. For the same reason, the final welding of the slipper path to the table—after the former had been fitted tightly over the ends of the radial plates, was made small, being only $^1/_8$-inch throat thickness. These precautions proved effective as the total distortion when the completed unit was put in the lathe for final machining was under 0.01 inch. This final machining consisted in fine machining the working face of the slipper path and also of the ball bearing housing. The complete table unit is shown in Fig. 3.

The pivot bracket locating the center ball bearing consists of a square slab 2 inches thick with anchoring plates welded on the underside for grouting into the concrete, and a solid forged pivot recessed into the slab. After the unit was welded, the pivot was carefully machined to fit the internal diameter of the ball bearing.

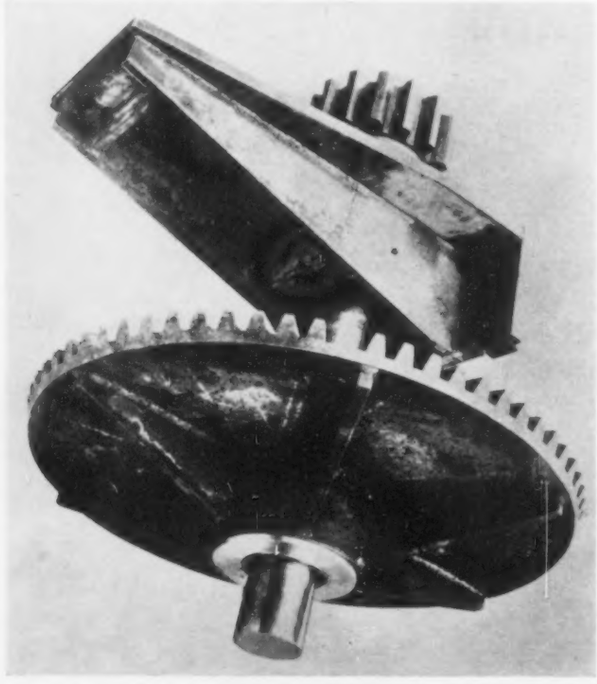


Fig. 4—Wheel with Bracket and Pinion

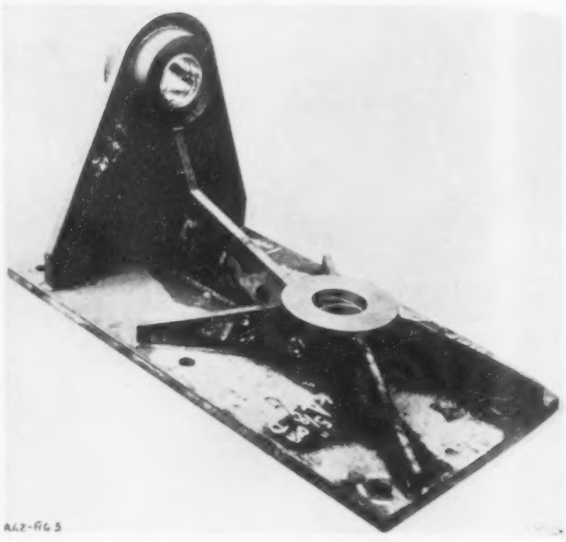


Fig. 5—Details of Pivot Bracket Which Carries the Bevels

The bevel wheel was made from a rolled slab $3^1/_2$ inches thick. This slab was first rough machined to shape with a central hole $8^1/_2$ inches diameter. A boss made of rolled bar was machined and fitted as shown. After welding the wheel was finished to sizes and the teeth cut. This wheel with bracket and rack pinion is shown in Fig. 4.

The bracket carrying the bevels is composed of plates one inch thick with rolled bars forming the bosses, and a stiffening rib along the bottom to form a key in the concrete. This bracket is shown in Fig. 5.

The saving in cost to our firm by adopting the welded design was, as already shown, £1880 ($9136.80), if considered simply as a machine to deal with the roller paths, or a saving of £1580 ($7678.80), if the welded machine was made equally suitable to the cast-iron design for general work. By far the greater part of this saving was due, not simply to substituting welding for castings, but by adopting an entirely new design which allowed methods of fabrication and machining to be adopted which were not applicable to a cast-iron design.

To estimate the benefits accruing to industry and to the social life of the community generally we have to consider the peculiar circumstances existing in the first half of 1937. During this period, which followed several years of very severe depression, the engineering industry was asked to largely augment its production in order to deal with a general increase in industrial activity and to accelerate the armament program. It was also hoped that it would quickly absorb very large numbers of unemployed men. The response was disappointing and the revival of the whole engineering industry was delayed by the lack of essential materials and machines as well as the scarcity of skilled men in essential branches of the industry. Iron and steel foundries particularly were unable to meet the demands made on them and the machine tool makers could not procure the necessary designers and draftsmen to deal with machinery problems. This difficulty was alleviated, if not solved, by the substitution of weldings made by men with a few months' training in place of founders for which a five years' apprenticeship is required, and by general engineering designers doing the work of those who specialized in the machine tool branch of the industry. By producing the machine I have described in nine weeks instead of eighteen months as required by the machine tool makers, the cranes were de-

livered to the time schedule, the shipyard allowed to function according to program and many men employed in the shipyard who would otherwise have been unemployed.

Many as are the benefits which industry and the community have derived from the use of weldings, one of the most important is the opportunity it has afforded of rapidly supplementing production of the whole or part of essential machines when the branches of the industry, which had specialized in these, were found incapable of meeting the demand for their products.

The machine described is typical of many which have been built in various parts of the country and they have played an essential part in the expansion of the industry as a whole in accelerating the armament program and in the absorption of a large number of unemployed men.

Lengthening No Problem

By J. S. GRAHAM, JR.*

ELECTRIC MOTOR SHAFTS READILY EXTENDED BY BRONZE-WELDING

THE extension of small electric motor shafts without removing the rotor is an operation that is frequently desired. A service shop which has been doing this type of work for several years has developed a particularly satisfactory method based on the use of bronze-welding.

Experience has shown that ordinary steel welding is not satisfactory because of scaling which reduces the journal diameter several thousandths of an inch.

BRONZE ROD IDEAL

Most motors run in bronze bearings, and it is normally not good practice to run moving parts in bearings of the same metal. It has been found, however, that bronze-welding rod is ideally suited to the job. The deposited bronze makes a perfect joint and is hard and tough enough to wear well against either bushing bronze or the so-called pot-metal alloys. In addition, the welding rod can be applied at a temperature low enough to prevent scaling.

WELDING PROCEDURE

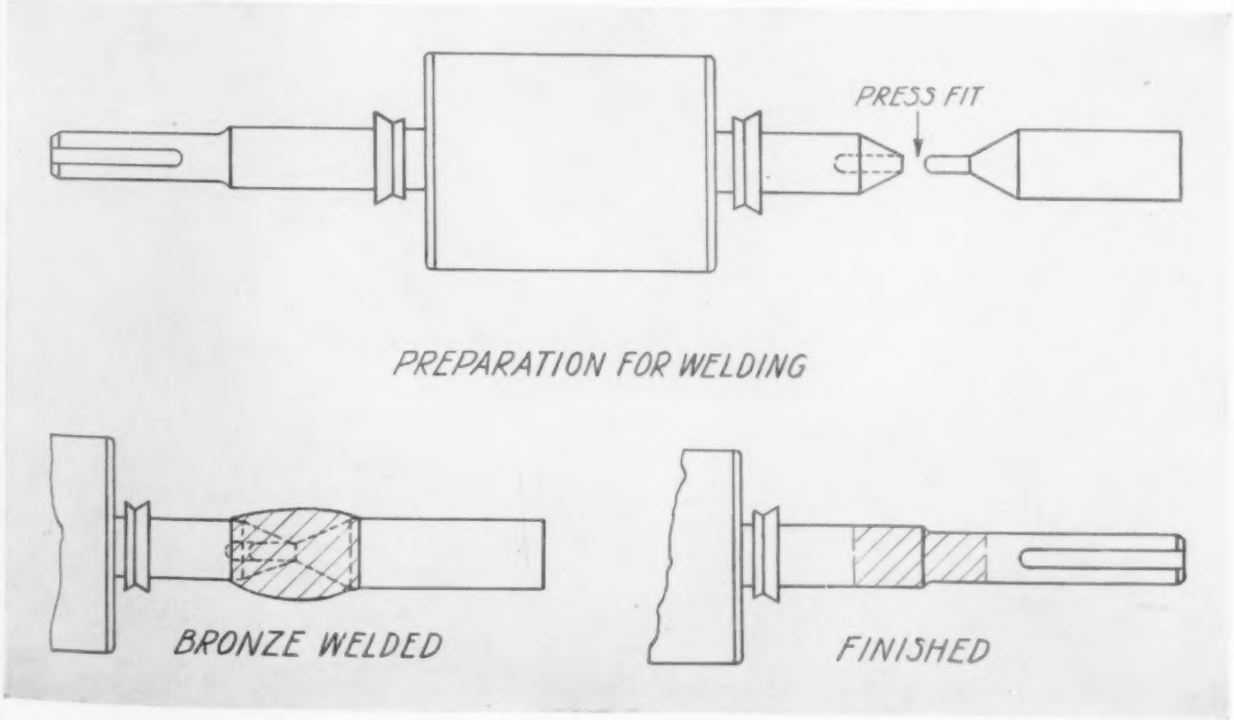
The accompanying sketches clearly illustrate the method used for extending the motor shafts. The end of the shaft to be lengthened is first tapered and drilled just large enough to take a small pilot. A piece of cold-rolled steel $^1/_{16}$ to $^1/_8$ inch larger in diameter than the desired finished size is then turned on one end and pressed into the shaft. This serves to line-up the work which is now ready to be welded.

The shaft is chucked and trued with an indicator or tied back on the center, the welded end being run in the steady rest just back of the weld. Bronze-welding rod is then applied. After welding, it has been found advisable to release whatever stresses may exist by first taking a roughing cut over the joint, then recentering and refinishing.

ONE-HALF THE COST

The cost of this method is about one-third to one-half of what it would ordinarily cost to machine and install a new shaft. From every angle it has proved the ideal way to lengthen electric motor shafts.

* General Publicity Department, The Linde Air Products Company, New York.



These Sketches Indicate Clearly the Method Used for Extending Motor Shafts

FABRICATION

By CLINTON A. WILKINSON* and G. E. THORNTON†

THE development of the Columbia River in the Pacific Northwest with its millions of horsepower of electric energy will give to the people of that area an opportunity of using two of the newest tools of modern industry for the benefit of the agricultural, timber and mining interests of the region.

These two modern industrial tools are the electric furnace for production of excellent steel from scrap metal and metallic arc and gas welding, combined with cutting from standard steel shapes for fabrication.

The electric furnace of today with its high efficiency operation in the production of steel from scrap metal provides a means of using the millions of tons of scrap metal in the area. The steel so produced could be used in the manufacture of certain types of agricultural implements, highway machinery, timber and lumber equipment and mining machinery.

Scrap metal is an important raw material of the Northwest. The freight into the area upon this commodity has been paid. It should never be allowed to leave the area, but should be used over and over for production of necessary equipment, pertinent to conditions existing in the Northwest.

A warning might be injected into the article here, concerning the disposition of scrap metal at present in vogue in the Northwest states. During the two years just passed, several million tons of the scrap metal have been shipped from the west ports to an ambitious power of the Far East. Such shipments should be prohibited through the enforcement of embargoes, if the metal is to be directly used for benefiting all interests of the West.

A survey of many pieces of equipment used by agriculture has shown that the individual parts of a large number of them are made from steel sheets, and standard structural shapes, combined with castings. Many of the castings could be replaced with parts fabricated from standard shapes, through the use of gas cutting and metallic arc and gas welding. The fabricated part would be stronger, lighter and cheaper than the cast part which it replaced and would need no expensive outlay for complicated equipment to produce.

* Student—Department of Mechanical Engineering, State College of Washington.
† Professor of Mechanical Engineering, State College of Washington.

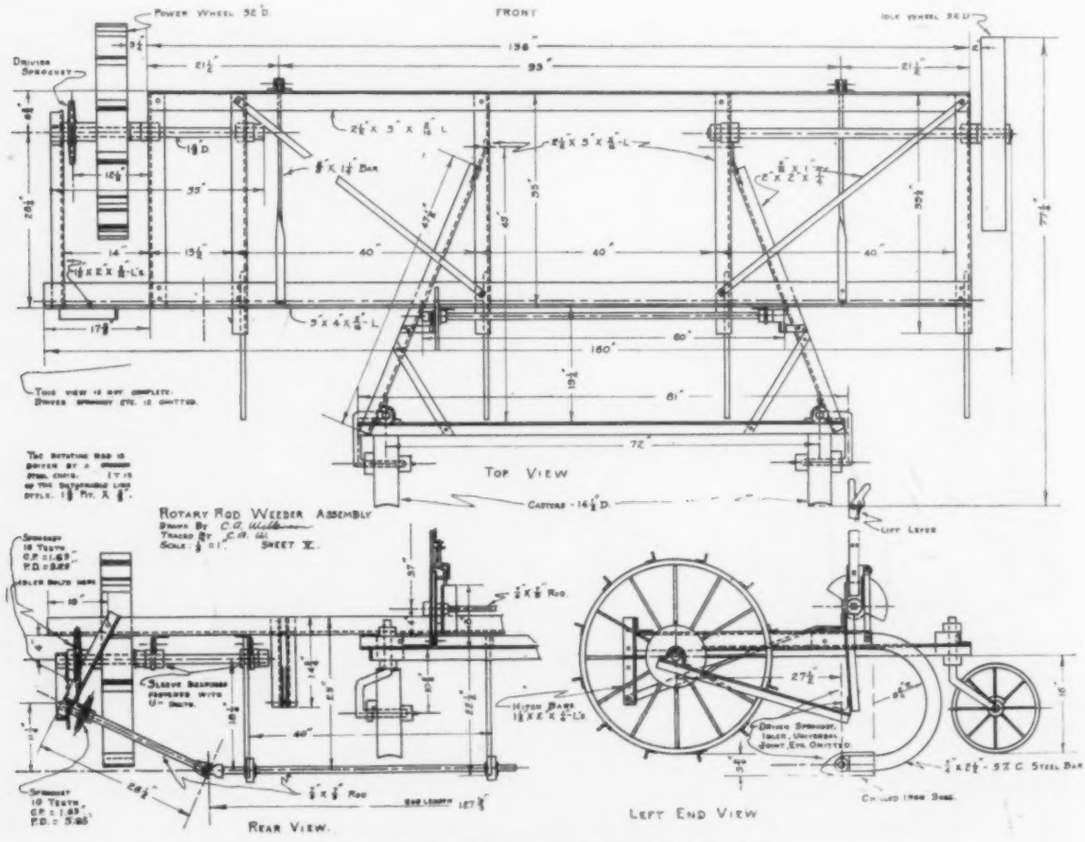


Fig. 1—Assembly Drawings of Rotary Rod Weeder

A survey of freight rates on machinery assembled in carload lots shows a very considerable increase in rate over that upon an equal weight shipped in standard shapes. This saving in freight could be passed on to the consumer. Fabrication locally would assist local labor. The load so produced would provide in a small way, an additional outlet for energy from the power developments of the Columbia. An analysis of certain conditions existing in the State of Washington is proportionally typical of the area as a whole.

The demand for agricultural implements depends not only upon the present land under cultivation, but also upon that being developed and reclaimed by irrigation. There are at present in the State of Washington, 14,680,097 acres of farm land under cultivation, ranging from production of fruits and vegetables through irrigation, to large scale wheat farming under dry land conditions. In 1935 this area produced crops valued at $120,422,000. The reclamation program at present under way, will add 1,300,000 acres to the present total. On the basis that an 80-acre irrigated farm under diversified conditions, will produce $4364 annually in gross income, the additional acreage added will produce $70,915,000 worth of new commodities annually.

The Farm Management Division of the U. S. Dept. of Agriculture gives the average value of farm implements per crop acre for irrigated farms in the State as $16.87. On this basis it would require $21,931,000 in new equipment to equip the farms in the Roza and Columbia Basin projects.

The possibility of new sales and the opportunity to replace yearly depreciations presages a rising industry too large to overlook.

The following survey of conditions existing over the nation as a whole, compared to those of the Northwest, presents interesting facts.

Items	1929 National	State of Washington	1925 National
Number of manufacturers	293	4	303
Wage earners	41,663	27	28,698
Wages	58,941,939	44,373	37,387,620
Materials and power costs	113,969,484	97,933	73,850,060
Value of products	277,884,978	270,464	169,467,966

The small number of agricultural machinery manufacturers in the Northwest, with attendant low value of their products compared to the amount used at present, and the possibility of that being used in the future again leads one to believe a very sizable new industry is possible in the Northwest.

A conservative value placed on this industry for the Northwest, embracing agriculture, timber, mining and others has been set at 15 to 20 million dollars annually.

On the basis of the value shown, a sampling analysis as to construction details was made of twenty representative agricultural implements. This sampling included both large and small equipment, as well as simple and complicated pieces of apparatus.

The sampling analysis could well be extended to cover all types of machinery, including lumber, mining, fishing, transportation, state highway and other industries. Such extension would require a fund to meet labor costs of such a survey and to meet the cost of operation of a design service for manufacturers who would be interested in applying welding practices to replace more expensive practices involving drilled and bolted, or riveted design.

A compilation of the data obtained from the sample survey of twenty representative agricultural implements is given below:

The percentage shown in the last column includes number of parts in the cut and drilled column, which can be cut from stock shapes, involving simple mechanical operations, plus the cast parts, which through redesign could be replaced with parts fabricated from standard shapes.

The percentage involves the number of parts which go to make up the finished machine. The value of these parts varies with type and use of the part. Large percentage of parts in certain cases represents small per cent of total cost; on the other hand, a small percentage of parts may represent the larger part of the cost.

The method of obtaining the data for each implement is shown in detail by the following sample analysis sheets of three of the twenty representative agricultural implements.

Table 1A for agriculture was duplicated for every type of industry shown in Table 1, such as Logging and Lumber, Mining, Highway, etc.

Analysis of Representative Implements

Name of Machine	Percentage of Parts Made by Different Processes: Forged	Cut and Drilled	Cast	Pressed or Drilled	Percentage of Parts to Be Made Locally: Welded	Cut from Shapes
1. Three bottom gang plow	25	25	45	5	25 %	25 %
2. Spike tooth harrow	58	42	..	...	1.2	42
3. Spring tooth harrow	49.7	29.9	..	21.4	3.6	24.9
4. Tractor disk harrow	30.9	51.5	17.6	...	4.4	51.5
5. Rotary hoe	5.3	33.6	60.1	1	61.9	33.6
6. Tractor lister	11.8	61.3	26.9	...	30.1	61.3
7. Clod crusher	..	25	74	1	74	25
8. Soil pulverizer	..	17.5	81	1.5	20	17.5
9. Pivot axle cultivator	16.5	64.25	16.5	2.75	22	64.25
10. Rotary rod weeder	..	55.3	44.7	...	55.3	44.7
11. Subsoil tiller	26.1	67.4	6.5	...	8.7	67.4
12. Grain drill	31.6	43.4	25	...	25.8	43.4
13. Potato planter	26	26	19	29	20.6	26
14. Potato digger	21.4	41	24.8	12.8	15.4	41
15. Side delivery hay rake	1.9	82.4	14.7	1	17.6	82.4
16. Sulky rake	1.1	77.6	18	3.3	33.4	77.6
17. Hay mower	45.3	13.3	41.4	...	16	13.3
18. Hay loader	5.8	42.2	52	...	49	42.2
19. Grain binder horse drawn	4.6	42.6	48.2	4.6	38	42.6
20. Combined harvester	12	44	44	...	31	44

Table 1—General Plan of Fabrication

- Fabrication
  - Value
    - Agricultural
      - By types
      - By counties
    - Logging and lumber
      - By types
      - By counties
    - Highway
      - By types
      - By districts
    - Mining
      - By types
      - Location: East Side; West Side
      - Service: Automobile: Tools; Accessories
    - Domestic
      - Heating
      - Cooling
      - Air conditioning
      - Cleaning
      - Washing
      - Cooking
      - Water heating
      - Cutlery and grinding
      - Lighting
      - Pumping water
      - Plumbing
    - Medical
      - Dental
      - Surgical
    - Hydraulic
      - City water supply
      - Sewage disposal
      - Irrigation
    - Chemical
    - Marine
    - Fisheries
    - Transportation
      - Rail
      - Water
      - Air
      - Bus and stage
    - Metallurgical
    - Construction
    - Power generation

NOTE: The remainder of table is omitted. Table included every industry and type of work carried on in the Northwest which presented an opportunity for fabrication.

Table 1A—Detailed Plan of Fabrication for Agriculture

- Agricultural
  - Types
    - Horticulture
      - Fruit
        - Cultivating
        - Ditching
        - Spraying
        - Harvesting
        - Storage
        - Preservation
        - Canning
      - Vegetables
        - Cultivating
        - Ditching
        - Planting
        - Soil Preparation
        - Harvesting
        - Storage
        - Packaging
        - Canning
    - Grain
      - Soil preparation
        - Plowing
        - Harrowing
        - Weeding
        - Rolling
        - Soil conservation
      - Seed preparation
        - Seed cleaning
        - Seed treating
        - Planting
      - Harvesting
        - Preparation of sacks
        - Combines
        - Stationary rigs
        - Storage
      - Uses
        - Milling
          - Domestic
          - Commercial
    - Stock
      - Dairy
        - Preparation
          - Butter
          - Cheese
          - Canned Milk
          - Ice Cream
          - Rawmilk
          - Cream
          - Powders

NOTE: Remainder of table omitted. Table included every minute detail of the agricultural industry which offered an opportunity for fabrication.

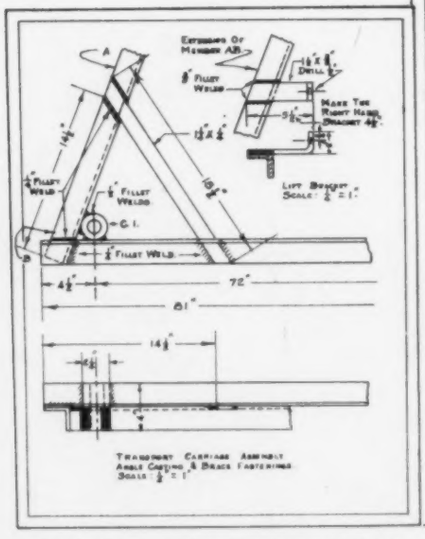


Fig. 2—Transport Carriage Assembly Detail

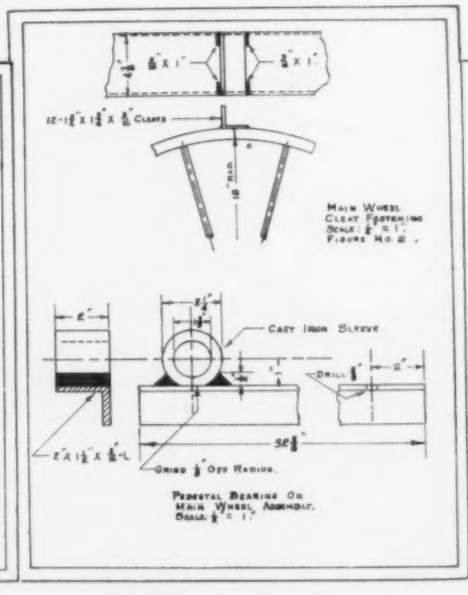


Fig. 3—Main Wheel Assembly Detail

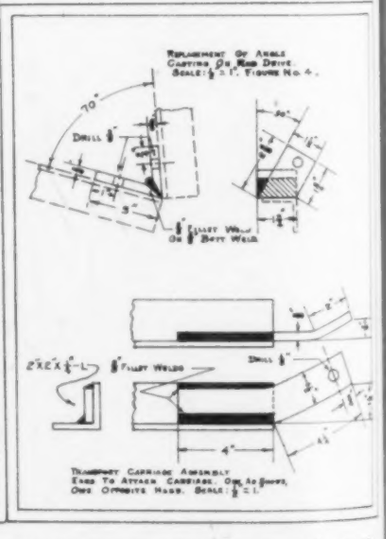


Fig. 4—Transport Carriage Assembly Detail

Table 2

Table VII from Survey

Clod Crusher—10 Foot

No.	Name of Part	Type of Stock	Metal	Manufacturing Operation	Possible to Weld
28	Toothed wheels		Iron	Castings	Yes
29	Flanged wheels		Iron	Castings	Yes
2	Wheel shaft bearing	Maple block	Wood		
1	Wheel shaft	Rod	Steel	Cut and drilled	
6	Spacers		Iron	Casting	Yes
1	Seat	Sheet	Steel	Pressed	
1	Seat standard	Strap	Iron	Bent-cut-drilled	
4	Frame pieces	Angle iron	Iron	Cut and drilled	
8	Frame braces	Strap	Iron	Cut and drilled	
3	Hitch straps	Strap	Iron	Cut and drilled	
2	Braces	Rods	Iron	Cut and drilled	
85	Major parts				

Summary of Clod Crusher

No.	Mfg. Operation	Per Cent of Whole
0	Forged	
63	Casting	74%
22	Cut and drilled	25%
1	Pressed	1%
63	Possible to weld	74%

Table 3

Table X from Survey

Rotary Rod Weeder—12 Foot

No.	Name of Part	Type of Stock	Metal	Manufacturing Operation	Possible to Weld
2	Wheel	Bar, rod	Steel-G. I.	Drill-cut bend-rivet	Yes
2	Caster wheels	Bar, rod	Steel-G. I.	Drill-cut bend-rivet	Yes
12	Frame	Angles	Steel	Cut-drill	Yes
6	Braces	Bar	Steel	Cut-drill	Yes
3	Shafts	Cold-rolled Bar			
6	Bearings	Cast	C. I.	Drill and cast	
3	Sprockets	Cast	C. I.	Bore and cast	
5	Angle fittings	Cast	C. I.	Drill and cast	2 Yes
1	Lever	Bar	Steel	Cut and drilled	
1	Lever bracket	Cast	C. I.	Drill	Yes
1	Ratchet	Cast	C. I.	Drill	
1	Lever arm	Bar	C. I.	Drill	Yes
2	Lever supports	L's	Steel	Cut and drilled	Yes
2	Hitch bars	L's	Steel	Cut and drilled	Yes
4	Shoe supports	Bar	Steel	Cut-drill-bend	
4	Shoes	Cast	C. I.	Cast-drill	
4	Rod-spools	Cast	C. I.	Cast-drill	
2	Rods (weeder)	Bar	Steel	Cut	
1	Universal joint	Cast	C. I.	Drill and cast	
1	Idler sprocket bracket	Cast	C. I.	Drill and cast	Yes
4	Caster hub collars	Cast	C. I.	Bar and cast	
67	Major parts				

Summary of Rotary Rod Weeder

No.	Mfg. Operation	Per Cent of Total Parts
34	Cut and drilled	55.3%
0	Forged	
30	Castings	44.7%
0	Pressed	
31	Possible to weld	46.2%

Table 4

Table XVII from Survey

Combine (Not Power Driven)

No.	Name of Part	Type of Stock	Metal	Manufacturing Operation	Possible to Weld
1	Front wheel		Iron	Casting	Yes
2	Main wheels	Strap, rod	Iron	Forging	Yes—2
1	Hand wheel		Iron	Casting	Yes
1	Hand pinion		Iron	Casting	Yes
1	Hand wheel rack		Iron	Casting	Yes
40	Frame braces	I & L-iron strap	Steel	Drilled	Yes—40
1	Front coupling	L-iron	Steel	Casting	
1	Ford motor	I-Beam		Cut	Yes
1	Conveyor feeder	Tube flighting	Iron	Welding	Yes
1	Conveyor shielding	Sheet	Galv. iron	Cut and riveted	
1	Sickle	Steel knives	Steel	Cut and drilled	
1	Sickle guard		Iron	Casting	Yes
2	Conveyor bearings		Iron	Casting	Yes—2
1	Conveyor sprocket		Iron	Casting	Yes
1	Thrashing reel	Wood-strap rod	Iron	Cut and drilled	
2	Reel sprocket		Iron	Casting	Yes—2
1	Harvester pan	Sheet	Galv. iron	Cut-bent drilled	
1	Tailings elevator	Sheet rivets	Galv. iron	Drilled cut-bent	
1	Grain chain and buckets	Sheet rivets	Iron	Cut Forged	
6	Elevator sprockets		Iron	Casting	Yes—6
1	Grain conveyor	Rod flighting	Iron	Welded cut	Yes
1	Taling conveyor	Rod flighting	Iron	Welded cut	Yes
1	Grain elevator	Sheet-rivets	Galv. iron	Cut-bent drilled	
1	Grain elevator				
1	Threshing cylinder	Rod sheet-strap	Iron	Cut-bent drilled	Yes
8	Cylinder rasp bars		Steel	Drop-forged	
2	Cylinder bearings		Iron	Casting	Yes—2
1	Cylinder sprocket		Iron	Casting	Yes
5	Concaves	Concave strap	Iron	Cut and drilled	Yes—5
1	Threshing beater	Rod, sheet	Galv.	Cut-bent-drilled	
2	Threshing beater bearing		Iron	Casting	Yes—2
1	Threshing raddle	Wood, cloth			
1	Separator raddle	Wood, cloth			
4	Raddle rollers	Cylinders	Iron	Forging	
2	Raddle sprockets		Iron	Casting	Yes—2
8	Raddle roller bearing		Iron	Casting	Yes—8
1	Separator fan	Wood, rod	Iron	Casting, cut-drill	Yes
1	Cleaner fan	Wood, rod	Iron	Cut-drill, casting	Yes
2	Fan sprockets		Iron	Casting	Yes—2
8	Fan bearings		Iron	Casting	Yes—8
1	Grain spout		Iron	Casting	Yes
1	Grain gate	Sheet, rod	Iron	Cut and drilled	
1	Grain bin	Sheet	Galv. iron	Cut and drilled	

Table 4 (*Continued*)

1	Weed-seed-screen	Sheet, Mesh	Iron	Cut and bent	
4	Separator beater rod	Rods	Iron	Cut	
8	Separator beater bearings		Iron	Casting	Yes—8
4	Beater fixtures	Sheet rod-wire	Iron	Cut-bent drilled	
4	Beater sprockets		Iron	Casting	Yes—4
2	Separator raddle rods	Rods	Iron	Cut	
1	Separator raddle	Wood, cloth			
2	Separator sprockets		Iron	Casting	Yes—2
1	Cleaner shoe	1-irons-sheet-wire	Iron	Cut-drilled riveted	
1	Cleaner shoe sprocket		Iron	Casting	Yes
1	Straw spreader	Sheet, strap	Iron	Cut and drilled	Yes
4	Separator roll bearing		Iron	Casting	Yes—4
2	Straw separator bearings		Iron	Casting	Yes—2
1	Straw separator sprocket		Iron	Casting	Yes
1	Partitions-shielding		Galv. iron	Cut-drilled rivet-bent	
159	Major parts				

Summary of Combine

No.	Name of Part Manufacturing Operation	Type of Stock	Metal Per Cent Total	Manufacturing Operation	Possible to Weld
19	Forging		12		
70	Cut and drilled		44		
70	Casting		44		
0	Pressed		0		
119	Possible to Weld		75		

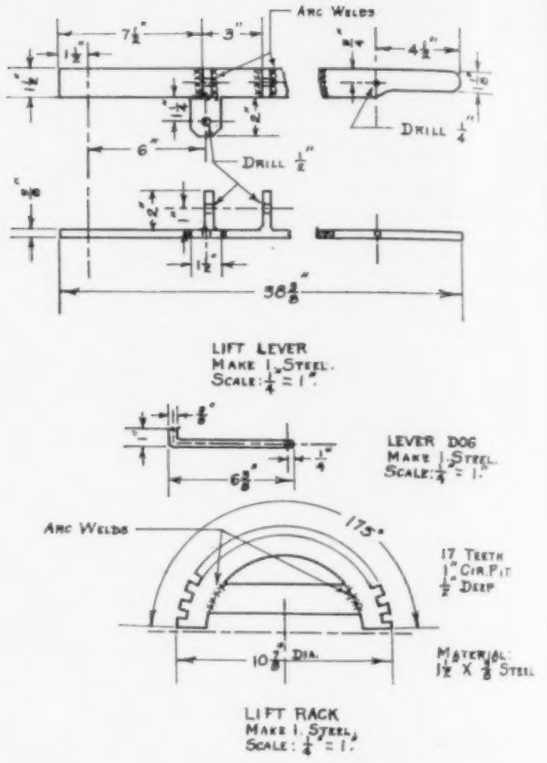


Fig. 7—Lift Lever Detail

Several implements from the representative group were redesigned completely to show replacement of castings with fabricated parts. Several drawings in connection with the redesign of a rotary rod weeder to replace castings and bolted, riveted design with fabricated parts is shown in Figs. 1 to 7 inclusive.

In addition to the complete redesign of the implement, cost analysis sheets covering all redesigned parts were prepared. This analysis, as shown in part in Fig. 8, covered name and number of part, type of weld, thickness of plate, number of passes, size of electrode, current in amperes, arc voltage, amount of electrode, speed, total cost, total time and power consumed.

The costs given in the analysis are based upon costs prevailing in the Northwest in the vicinity of Pullman, Washington. From this preliminary survey it has been found that fabrication of agricultural machinery in whole or in part in the Pacific Northwest is feasible, practical and economical.

The preliminary steps in the program will be a campaign of education to bring the possibilities of fabrication to the people of the area; and second, the development of a plan of cooperation between the eastern manufacturer and the western consumer to the end that fabrication methods for production of machinery adapted to the Northwest may be brought in part to the area.

Fig. 5—Main Frame Assembly

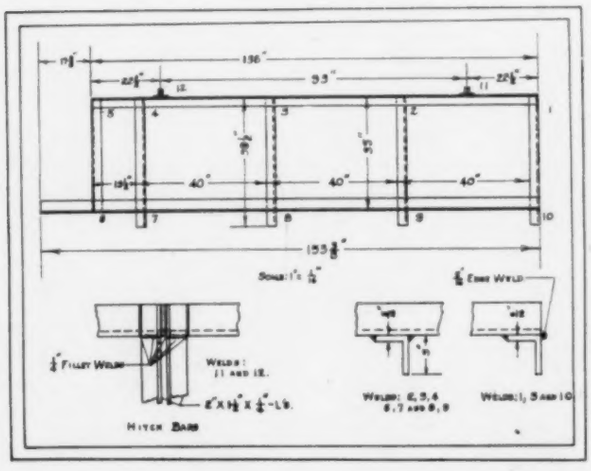
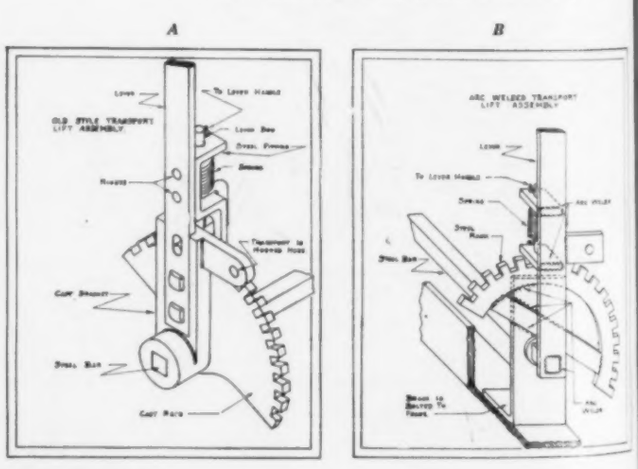


Fig. 6—(*A*) Cast Transport Lift Assembly

(*B*) Arc-Welded Transport Lift Assembly



Cost Analysis For Arc-Welded Construction.

Sketch No.	Parts & Assembly	Type of Weld Plate Thick	Passes	Wire Size	Current	Arc Volts	Lbs. Electr. / Ft. of Weld	Actual Weld Speed / Hr.	Total Cost	Total Time	Power Actually Used
1	Frame Side Bars & Rails	Fillet ⅜"	1	¼"	250	30	.19	50			
					Labor $.90/hr → 120 →				.018		
					Power .02¢/Kw. Hr.		250 x 30 x 1 / 50 x 50 x 1000		.002		
					Electrode .08¢/lb.		.19 x .08 →		.015		
					Machine Eff. = 50%				$.039/Ft.		Weld
	Welds 1-10-5				4" + 3" + 3" = 10"		12/12 x .039 =		.032		
	"				Time = ½ / 60					1 min.	
					Power = 250 x 30 x 1 / .50 x 60 x 1000					=	.0025
	Welds 1-10-5	Edge ⅜"									
					Length = 10"						
					Cost / Ft = $.039						
					10/12 x .039				= .032		
					Time 1 Min. (As Above) =					1 min	
					Power Same As Above =						.0025
	Welds 2-3-4-6 7-8-9	Lap ⅜"			Total Length = 50"						
					50/12 x .039 =				.162		
					Time 50/2 / 60/60 =					50	
					Power = 250 x 30 x 5.8 / .50 x 60 x 1000 =						.435
	Hitch Bars To Front Rail H-12	⅜" Lap			2(10+3) = 26		26/12(.039)		.084		
					Time 26/2 / 50/60 =					.259	
					Power = .0025 x 2.59 =						.0064

Fig. 8

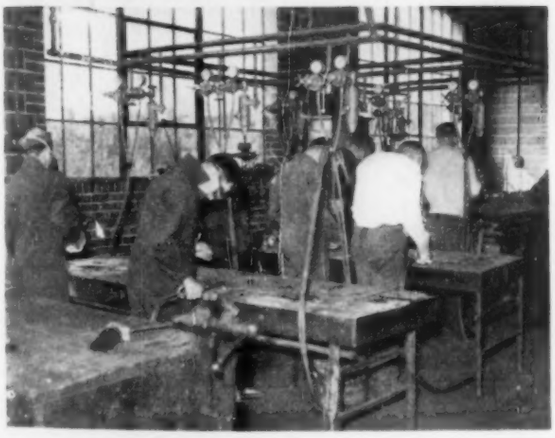


Fig. 9—Part of Educational Program

The educational program is already under way as evidenced in Figs. 9 and 10, which are typical of many institutions of the West.

Fabrication methods through welding are being applied to design of new and revolutionary equipment to meet the needs in special fields in the Northwest.

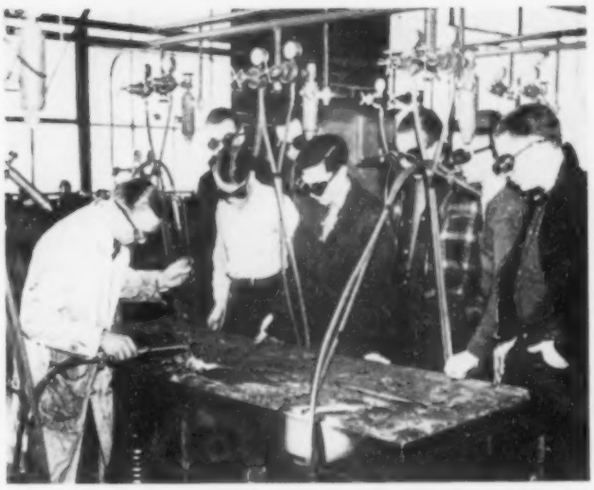


Fig. 10—Typical Welding Class

Fig. 11—Combined Harvester

This equipment includes a new type plow to assist in deterring erosion. The plow is of a special design that throws the land uphill and can be used without burning the stubble from the fields. Heating equipment for use in small homes utilizes fabrication as the manufacturing medium. This furnace is to be self-cleaning and is to use straw as an automatic fired fuel. Heat storage equipment to utilize off-peak power from Grand Coulee Dam for heating of homes in the Columbia Basin area is being designed through the use of fabrication. A study of machinery designed for making of brick from diatomaceous earth for house construction in the Basin area is also using fabrication through cutting and welding as a manufacturing medium. Highway machinery to be designed and constructed during winter months in the district highway shops of the state through cutting and welding is also being studied.

The production of machinery adapted to use in the Northwest through fabrication is of vital importance to agricultural and other interests. The lay of the land (Fig. 11) controls certain construction details which are directly reflected in cost of operation. Western designed machinery, western made through fabrication, will give to the West cheaper, lighter, stronger implements and work to the benefit of western labor, western capital and develop a use for cheap, abundant western power.

THE APPLICATION OF RESISTANCE Welding to Small Parts

By PAUL G. WEILLER*

RESISTANCE welding is as a matter of course as well suited to the fabrication of small objects as to the heaviest work. Extensive use of spot welding in the manufacture of radio tubes and similar devices amply bears this out.

Peculiarities inherent to most businesses making large use of small parts have however proved a considerable obstacle in the way of wide spread use of resistance welding for very light work.

A large proportion of small objects are of odd shapes and made of nonferrous metals or special iron alloys which require great care in tooling and setting up at the work for best results.

Many small objects require great accuracy of location of parts which is not easily obtained with ordinary welders. For example the settings for stones on gold or platinum rings must be located with an accuracy of ±0.001 inch. Similar accuracies are required in welding iridium points to fountain pen nibs.

At times there are stringent appearance requirements to be complied with. Welds must be made invisible at least on one face of the work.

The rapid handling of odd shaped small parts is very difficult unless welding tools are carefully designed. Last but not least, detailed knowledge of the possibilities of spot welding for difficult jobs is not common among metal fabricators.

WHAT METALS CAN BE SPOT WELDED?

Practically all metals and alloys can be spot welded under proper conditions. A few of them are, however, generally unsuitable for assembly by resistance welding.

Such soft metals as tin, die casting alloys and pewter will weld rather easily, aluminum can be welded to steel under proper conditions; brass and steel weld nicely.

To weld sheet copper or screw machine brass (leaded brass) is however so difficult as to be impractical for most purposes. Tungsten sheet is as troublesome as copper sheet. It is however easy to weld copper wire to copper wire, copper wire to tinned lugs, copper braid to copper or steel, tungsten wire to tungsten wire provided that suitable methods are used.

Whenever a new material goes into parts which must be welded it is safe to assume that they can be welded, though the working out of the proper conditions may require a great deal of careful experimentation.

Generally speaking metals can be divided into two distinct groups in respect to their behavior when they are being welded.

One group contains platinum, iron, nickel and some alloys. These metals will coalesce when heated under pressure at temperatures considerably below their melting point. Platinum for instance can be welded at 700° C., while its melting point is at about 1800°. Two pieces of the metal can be joined at any temperature within this range. For steel the range is not as wide as for platinum, but there is ample leeway to allow for variations of time, current and pressure as they occur in rough work. It is the ability of these metals to weld considerably below the melting point which made them particularly suited to resistance welding.

The other group, comprising nearly all other metals and the majority of alloys, ferrous and non-ferrous, has a sharp melting point. They remain solid and non-coalescing up to the melting point and liquefy suddenly when the melting temperature is reached.

The outstanding example of this group is pure copper.

It is worth noting, that pure iron has a wide welding range, its alloys, particularly those high in carbon have a much narrower welding range or belong to the second group. Copper on the other hand has practically no welding range and therefore is difficult to weld while brass shows fair welding properties and silicon copper welds nearly as easily as steel.

WHAT TO LOOK OUT FOR WHEN WELDING SMALL PARTS

The welding of small parts is subject to the same rules which apply to the fabrication of larger pieces but because of the frequent use of alloys and because of the small dimensions a slight neglect of these rules will bring about complete failure on small objects while irregular welds might be the only penalty if the pieces were large.

The welding properties of metals were discussed because their understanding is necessary to a proper interpretation of what follows.

Metals with a wide welding range can be successfully spot welded either with short time (one or two cycles) or with long time (five cycles or more). The choice of welding time depends on results desired and often on expediency. If the best possible appearance or complete absence of oxidation is required the shortest available welding time and considerable uniformity of all conditions is essential. Where appearance does not matter and where first cost of equipment should be low or where the pieces to be welded are buckled or otherwise non-uniform, a longer welding time is advisable.

Metals of the second group can be welded only with short time impulses. The reason is obvious. As these metals must be completely liquefied to coalesce, a hole results whenever the metal is melted through its entire thickness. It is therefore necessary to keep a solid outer skin which will prevent the molten metal from running out. This can be done successfully only by keeping the temperature gradient very steep, the source of heat confined to a definite small area of the cross-section.

To comply with all these requirements, short time, a relatively small diameter of the contact area, and large currents are necessary.

* Consulting Engineer.

Under proper conditions the metal will melt completely through about half the thickness of the piece but it will chill and solidify before the outside surface has reached melting heat.

Where the greatest attainable strength is required of spot welds or where metals have a tendency to become brittle when subjected to spot welding operations it is necessary to consider the metallurgical structure of the welds.

It is often assumed that spot welds must show the structure of cast metal. That is not always true.

When the metals of the second group are spot welded they must of course be melted at the joint but the structure of the finished weld may nevertheless have no similarity to that of cast metal because of vastly different cooling conditions.

If the weld is made at about one or two cycles it is heated and cooled rapidly. The structure of the weld will be that of chilled metal.

Copper wire if welded with very short time will produce a flexible fine grained joint. Long time makes for brittleness. Spring steel will make a glass hard and extremely brittle weld even under average welding conditions. The weld must be either done with unusually long time or it must be annealed.

It is safe to assume that as a rule any structure which can be produced by melting and cooling slowly or rapidly can be produced in a spot weld.

The fibrous structure of rolled material can of course not be reproduced after the material has been melted. Therefore welds made on rolled metals of the second group cannot have the strength of the original material.

If rolled shapes of metals of the first group are resistance welded the original structure is largely preserved because the metal is not completely melted. The tensile strength of such welds if properly accomplished is the equal of the strength of the original material of the same cross section.

The cross section of the weld and with it, the volume of metal which must be heated depends on the area of contact between the work piece and the smaller of the two electrodes.

With large pieces of metals of the first group the effect of small changes in electrode area is not very noticeable. With high brass or other copper alloys of good conductivity as with aluminum the electrodes must be dressed frequently, particularly for small diameter welds. To avoid having to dress tips too often, the time can be gradually increased to make up for increased electrode area. A precision timer is of course essential for this type of work.

The operator should be provided with about two dozen easily exchangeable electrode tips which are sent to the tool crib every day for reconditioning. With proper tools an electrode can be dressed in a few minutes.

Reliable pressure control is as important as accurate timing. The greater the electrode pressure employed, the more power is necessary to make a weld. If high pressure is employed on aluminum, or high brass inordinately large welders are required, which are inconvenient for the handling of small objects, and often too expensive.

It is of the utmost importance to have the parts to be welded properly formed. The use of a spot welder simultaneously as welder and straightening press can lead only to increased scrap, particularly when low electrode pressures are employed.

Most metal working shops are using only the primary connections of the welder to regulate power. This method is too rough for many purposes. Plants which make a great variety of welded parts should provide some of their welders with auto transformers with ten taps spread over one half of the winding and brought out to a plug board as shown by the diagram Fig. 1. By using any one of the taps with either one or the other line terminal twenty different voltages can be obtained from the auto transformer. If the welder has eight heats a total of 160 different heats can be obtained without much trouble from this combination, and at slight expense for equipment.

Auto transformers sell for about half the price of the equivalent welding transformer; the cost of a plug board is trifling compared with that of a rotary switch serving the same purpose.

The power lines for welding equipment should be carefully laid out. Good makes of welders with short horns will deliver from 3 to 5 times the rated current. If the supply transformer and line are not properly dimensioned there will be a substantial drop in voltage at the welder terminals, particularly whenever more than one welder happen to draw current at the same instant. Any sudden change of voltage exceeding 5% will result in spoiled work.

Whenever auto transformers are used, the switching device should be inserted between the auto transformer and the line, not between the auto transformer and the welder. The auto transformer left on the line with no load between welds has a very poor power factor because it is a purely inductive load.

Oil has no effect on spot welds. It is not necessary to clean parts which come from the presses coated with oil.

Contrary to a current belief iron oxides or even a slight coating of rust have little or no effect on welds but heavy oxide coatings like that on blue anneal will make the weld brittle. This is due to the absorption of the oxide by the steel, not to the electrical properties of the oxide.

Brass and other copper alloy must be bright for spot welding because the oxides of some of the alloying metals like zinc and tin are of poor conductivity.

The slight coating of oxide on aluminum as it comes from the mill is not detrimental, heavy oxide coatings must be removed before welding.

Stainless steel fresh from the mill can be spot welded without further cleaning. After exposure to the air for some time stainless steel forms an invisible coating which makes good welds impossible. The coating can be easily removed by washing or thorough wiping.

SOME PRACTICAL APPLICATIONS OF SPOT WELDING TO SMALL PARTS

Since the beginnings of the industry iridium tips had been silver or gold soldered to the body of the fountain pen nib by hand. Natural iridium grains were not sufficiently uniform in size and could not be handled mechanically.

Recently osmiridium grains of uniform size were produced and used for tipping fountain pens. To replace hand work by an automatic machine became now feasible.

At present most fountain pen nibs are tipped on an automatic machine at the rate of 30 per minute. The osmiridium grains are placed in a hopper from which a finger picks one at a time and feeds it to a channel which in turn deposits it in a groove of the lower electrode. It is properly located by two fingers. The pen nib body is inserted by the operator in a fixture fastened to the upper electrode or ram. The latter descends until the pen body makes contact with the osmiridium grain. At this moment current is admitted by a precision timer and the ram is raised after the weld is made.

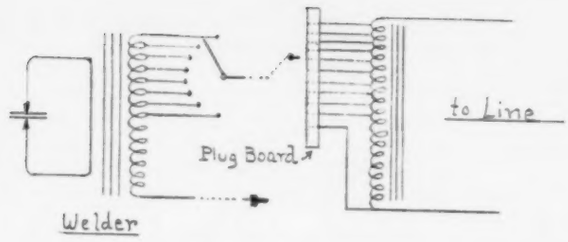


Fig. 1

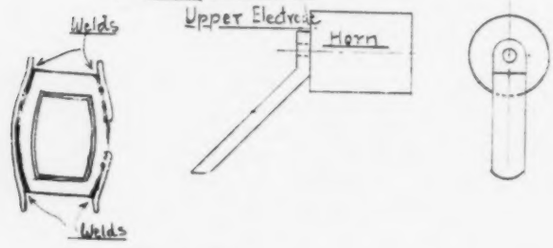


Fig. 2

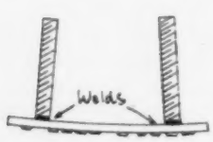


Fig. 3

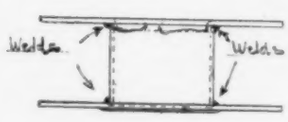


Fig. 4

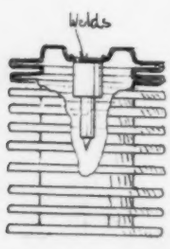


Fig. 5

It was found that D.C. permitted more accurate and reliable adjustments than A.C. welding current delivered by small transformers. Therefore, a small plating generator is being used to deliver the necessary power. The timer is directly in series with the welding electrodes.

This welding method is used for both gold and stainless steel pens. The pressure is only a few ounces exercised by the weight of the ram itself. 98% of the welds are satisfactory. Needles for sound reproduction can be tipped by the same method.

Resistance welding is applicable to many fabricating problems in the manufacture of watch cases.

In addition to precious metals a great variety of alloys, mostly non-ferrous, are used.

On high-grade watch cases, every joint must show a smooth fillet. Therefore welding is employed mainly to locate the parts. Formerly watch cases or jewelry parts were carefully assembled by highly skilled workers and wired in place, then they were soldered with silver or gold alloys. This process was tedious and costly but it did not require perfect fit because the solder would fill out any interstices produced by inaccurate forming.

The parts intended for welding however must be as perfect as forming processes can produce them. They are assembled in a fixture, which is often part of the welding electrodes, and welded.

The operation can be performed by unskilled labor and takes little time. Of one particular watch case with from eight to twelve welds, each operator produced about 100 per hour.

If the watch case is to be a high-grade product silver or gold solder is flowed over the welds. With the parts solidly held together by the welds soldering can be done very quickly and reliably by half skilled labor. For cheap watch cases soldering over the welds is not resorted to. It becomes, however, necessary to form the parts with very accurate dies to make them fit properly without leaving interstices which would affect the appearance of the finished product adversely.

The so-called pendant, that is the part of the watch case through which the winding stem enters can be easily welded. To prevent the appearance of a visible joint which would collect dust and become black later on a ring weld is made. The case body is flat at the proper place, the pendant is machined to a hollow cone with a slight slope.

In this way the flash which is produced by the melted metal will fill out part of the cone instead of appearing on the outside.

If the pendant is not of circular cross section a suitable type of hollow can be produced by an embossing operation. The movements of the average commercial welders are not always sufficiently accurate for this type of work. It is then preferable to build a fixture comprising both electrodes and the holding member with suitable guides. The whole assembly is clamped to the lower electrode. The tool is designed somewhat like a subpress used for punching or forming.

An interesting example is the watch case bezel sketched in Fig. 2.

This consists of two nested stampings of nickel silver and three pieces of half round wire which are assembled entirely by welding. All parts are first assembled in a holding fixture. The fixture is clamped to the lower electrode. The upper electrode slants at approximately 45° and is horizontally swivelled. The four lower welds are made first, then the entire fixture is turned over so that the other side of the case can be welded. The welds are entirely invisible on the outside of the watch case, even if the parts have been polished before welding.

This job presented considerable difficulty because the alloy selected for the watch case was not particularly suitable for spot welding. If all conditions were not correctly maintained, splashing or burning through occurred quite frequently.

Several weeks were spent on correcting the dies used in producing the parts and on the welding jig. The method is now in use two years with a minimum of trouble. Figure 3 shows an example of steel studs welded to a brass name plate. The particular name plate was the monogram of the Silver Streak Pontiac. The studs were about a quarter inch diameter and had to be welded to the name plate through their entire cross section. The joint is entirely invisible. No polishing or touching up of the name plate after welding was required.

For this type of work the lower electrode can be a massive copper bar hollowed out to fit the general shape of the name plate, if the latter is curved. If the name plate is embossed it is not always necessary to emboss the electrode. If the item is, however, produced in large quantities it is preferable to strike the electrode with a male embossing die so that the name plate would fit closely. This is an easy way to locate the studs accu-

rately. The lower electrode can be made to slide in a groove with two stops so that first one, then the other stud can be welded in its proper position. For best results the studs must be clamped within the upper electrode by a cam fixture, built in such a fashion that the current is admitted to the studs no further than one quarter inch from the weld. If the current is admitted further from the weld than one quarter inch or if the studs are simply pushed into a hole in the upper electrode instead of being solidly clamped, a poor looking weld and marring of the name plate will result. The studs will get hot and may be bent out of shape or the threads may be deformed. It is necessary to use short time. One cycle is best.

Figure 4 shows the assembly by projection welding of a typewriter ribbon spool. The ferrule is designed with four projections at each end. The ferrule and the two heads of the spool are assembled in a suitable jig and welded between two flat copper plates with about two cycles.

Figure 5 shows the assembly of a copper bellows with its needle valve. The part belongs to a refrigerator thermostat.

This was a particularly difficult job because of the high conductivity of all component parts. In spite of the fact that the weld had a diameter of only one-sixteenth inch, a 60 kva. spot welder was required. Great difficulties were experienced because the flattening of the conical upper electrode required frequent adjustment of time and power.

In the manufacture of wire wound resistors it is desirable to make a reliable mechanical and electrical connection between the resistance wire and the terminal straps. Silver soldering is resorted to by some manufacturers but it is too expensive for quantity production of small resistors.

Therefore the connection is mostly made merely by winding the resistor wire ends around some part of the terminal. To weld the wire to the terminal is an ideal solution. At present resistor terminals are mostly copper straps. The nichrome wire which is universally used becomes brittle when heated to welding temperature. Any weld must therefore be performed in such a fashion that the wire is not melted. It is, therefore, advisable to replace copper terminals by a metal or alloy of the first group, that is, a metal which will weld below the melting point. Monel metal and the various silicon copper alloys serve the purpose quite well. At one cycle even 0.001 wire can be welded to these metals.

Some of the cheaper grades of table knives consist of a forged stainless steel blade provided with a tang at one end which is cemented or soldered into the cavity of the steel handle. The forming of the tang entails some cost for tools and trimmings, which are wasted. It appeared desirable to eliminate the tang entirely by welding the blade directly to the handle.

The assembly can be carried out by butt-flash welding. Blade and handle must be securely and accurately located in fixtures connected to the welding electrodes, the current being admitted as closely to the weld as possible. The blade should never protrude more than $1/8$ inch from its clamp. The blade fixture should be light for low inertia, it should be pushed home by a spring which is accurately adjustable. The welding is done at one cycle. Weight of fixture and spring pressure must be so related that the push-up can take place in less time than one cycle. All parts of the welder must be perfectly aligned and should have a minimum of play. Misalignment of a few thousands of an inch will cause failures.

When welding times of more than one cycle are employed the heat will travel along the blade and cause distortion. At one cycle the metal is chilled and the weld is so brittle that the blade breaks off if it is dropped to the ground. It is therefore necessary to use two interlocked timers, one set at one cycle, the other at from one to two seconds for annealing.

The timer set at one cycle is connected to a transformer tap of sufficient voltage to produce a weld, the slow timer is connected to a lower voltage, which is only sufficient to produce anealing heat.

The welding cycle is started with the motion of the electrodes toward each other until the spring is compressed to the proper degree. Then a cam switch triggers off the one cycle timer which in turn starts the slow timer after the weld is completed. The fixtures have to be opened and the finished knife released before the electrodes are again moved to their initial position.

As all operations are automatic, unskilled operators can be used. The anealing time and the power required depend on the type of steel and the dimensions of the blade. The proper settings must be found by trial and error.

Copper wire, stranded flexible cable or braid can be welded to tinned lugs or terminal blocks without difficulty if a precision timer is used. Copper wire cross welds can be made. Copper wire or braid can be welded to steel radio chassis.

After the operators acquire some experience with this type of work no difficulty should be experienced in handling flexible cable up to $1/4$ inch diameter or braid of any width and wire down to 0.001.

Adaptation of resistance welding to radio receivers is however another matter. Few places in a radio chassis are accessible to the current pattern of spot welders. One solution of this problem can be found in welding the connecting wires to tube sockets, transformers and other components before they are mounted on the frame. Only a relatively small number of connections are left to be soldered after the components are in place.

This method of operation has some drawbacks. While at present some components are carried to the assembly line thrown at random into conveyor boxes and others are closely stacked on trays, the handling of components with several wires dangling from them, requires more space and careful handling.

Small welders with plier like electrodes have been suspended above the assembly bench or conveyor so that they are not in the way. The welding pliers are small enough to reach many of the joints in the chassis.

Welding of this type requires only small transformers for ordinary wire joints. At one cycle a 5 kva. welder is ample. If a shorter welding time is desirable, transformers should have a 10 kva. rating (30 kva. actual output).

Instead of using timers one may discharge a condenser through the transformer primary.

Welding has found some practical application in place of soldering on radio receiver chassis and will undoubtedly make great inroads into the consumption of solder but progress is necessarily slow. A considerable amount of redesigning will have to be done to make all parts of a receiver sufficiently accessible for welding.

Spiders for inexpensive lamp shades consist of a brass plated sheet steel ring to which steel wires are welded. The brass coating is thin and easily destroyed. Short time welding will produce perfect joints without a trace of discoloration of the metal surrounding the weld.

When metal parts are designed for large scale production, the limitations of machine tools and dies are carefully considered. Large sums are being paid for up to date equipment.

Resistance welding has however been the cinderella of production shops so long, that it is often hard to induce the powers that be to appropriate amounts of money sufficient to purchase the best available welding equipments.

Many plants are still equipped with simple, old style welders. Parts which were designed for riveting or bolting are being spot welded. Therefore the possibilities of resistance welding are far from being exhausted, in fact we have barely scratched the surface.

ESTIMATING THE COST OF Arc Welding*

By R. F. WYLER and S. C. SMITH†

THE weight of electrodes, of either bare or thinly coated, or heavily coated types, which will normally be required per linear foot for arc welding various types of joints, and the volume and weight of the steel deposited are given in the tables in this article. This information is valuable to those who are engaged in estimating the cost of arc-welded structures or in purchasing electrodes for their construction. While the cost of structural steel is only a few cents per pound, the total cost of the connecting metal deposited by the arc may amount to as much as a dollar per pound so that a reasonably close estimate of the amount of electrode required is essential to accurate cost prediction.

The basic information required for computing costs is the amount of weld metal required to fill the joints. This will vary widely, depending on the preparation given the joints. The parent metal which is removed in joint preparation to facilitate manipulation of the arc and complete fusion in the joint must be replaced by arc-deposited metal. As there is a wide variety of joints in use, common types of which are indicated by the sketches included in the tables, calculation of the volume and weight of deposited steel from the geometry of the joints becomes a very tedious process. These tables, however, give the required volume and weight per linear foot, so that most of the time-consuming work is eliminated.

In calculating these tables, the amount of deposited metal required is based on joint preparations as indicated in the accompanying sketches, and figures are given for the joints both with and without the reinforcement shown as R in the sketches. Reinforcement is sometimes calculated as $W/8$, that is, $^1/_8$ of the width of the bead at the top, but this factor depends on the operator's technique and on the characteristics of the electrode employed. As the reinforcement usually runs between $^1/_{16}$ and $^1/_8$ inch, the values of 0.07 and 0.08 inch, shown in the sketches, represent average values for good present-day practice.

The weight of electrode required for a joint differs from the weight of metal deposited in the joint by the electrode losses, consisting of scrap-ends which are thrown away when the electrodes have been used down to a stub, and the spatter-and-flux loss inherent in the arc-welding process. Both these losses are variable, the first depending on the care and economy of the welding operator and on the type of joint being welded while the second depends on the characteristics of the electrode and the type and position of the joint. Scrap-end losses would be expected to be less when welding an outside corner joint than when welding in a deep groove. Spatter-and-flux loss would be greater when welding overhead than when making a positioned fillet. As a result of these variations, scrap-end loss runs from 10 to 20 per cent for 14-inch electrodes; spatter-and-flux losses run from 8 to 15 per cent for bare and thinly coated electrodes, and from 15 to 35 per cent for heavily coated electrodes.

In order to give directly in the tables a fair approximation of electrode requirements, electrode losses have been included in the figures for the weight of steel deposited in the joint, the results being tabulated for bare, thinly coated, and heavily coated types of electrodes. These columns are based on an assumed average figure of 17 per cent for scrap-end loss, 13 per cent spatter-and-flux loss for bare and thinly coated electrodes, and 27 per cent for heavily coated electrodes. It is suggested that users of these tables check the electrode losses prevailing in their own shops against the average figures just mentioned to arrive at correction factors which may be applied to the tabulated values. In cases where electrode losses are accurately known for a specific application, more accurate results can of course be obtained by calculating from the weight of metal deposited in the joint, using the formula:

Weight of electrode required is

$$\frac{\text{Weight of steel deposited}}{1 - (\text{Total electrode losses})}$$

Estimates of the cost of labor and the cost of power for the arc required for a given job may be figured from the weight of electrode required. Simple factors may be derived from experience which, applied to the total weight of electrode, will give total cost for labor and for power. As these factors will of course depend on the efficiency of the welding operators or the piece-rates established in the welding shop and on the power rates, no attempt is made here to furnish these factors. It should be noted that where piece-rates are not established, the type of joint will largely affect the labor-cost factor which should be used because certain joints, such as high-quality vertical and overhead fillets, require much more time for the consumption of each electrode than do welds in the horizontal position where higher currents and higher speeds will be used.

In some shops, calculations of power and labor requirements are made from the cost of electrode, using blanket factors for various classes of work. For example, the cost of labor might be figured as three times the cost of electrodes, and the cost of power as 0.2 the cost of electrodes. On large jobs requiring the welding of many types of joints and otherwise following the trend of the over-all shop conditions, this is probably as accurate a method as any, and has the advantage that the required multipliers can be readily determined from existing records of electrode costs, payrolls and power bills.

* Reprinted from November 1938 issue *General Electric Review*.
† Industrial Department, General Electric Company.

TABLE II ELECTRODE REQUIREMENTS FOR VARIOUS TYPES OF WELDS

TABLE I ELECTRODE REQUIREMENTS FOR VARIOUS TYPES OF WELDS

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TABLE I
ELECTRODE REQUIREMENTS FOR VARIOUS TYPES OF WELDS
(Manual Welding)

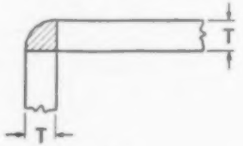
TYPE OF WELD	Size of Fillet L	WEIGHT OF ELECTRODES REQUIRED IN POUNDS PER LINEAR FOOT (Approx)		AMOUNT OF STEEL DEPOSITED PER LINEAR FOOT	
		Bare and Thinly Coated	Heavily Coated	Cu In.	Pounds
NORMAL FILLET Fig. 1	1/8	0.039	0.048	0.094	0.027
	3/16	0.090	0.113	0.222	0.063
	1/4	0.151	0.189	0.375	0.106
	5/16	0.237	0.296	0.585	0.166
	3/8	0.341	0.427	0.844	0.239
	1/2	0.607	0.760	1.500	0.425
	5/8	0.947	1.185	2.340	0.663
	3/4	1.365	1.705	3.375	0.955
	1	2.420	3.030	6.000	1.698
POSITIONED FILLET Fig. 2	1/4		0.212	0.420	0.119
	5/16		0.334	0.660	0.187
	3/8		0.486	0.960	0.272
	1/2		0.850	1.680	0.475
	5/8		1.275	2.520	0.713
	3/4		1.820	3.600	1.020
	1		3.210	6.350	1.800
OUTSIDE CORNER FILLET  Fig. 3	T Inches				
	1/8	0.06	0.07	0.144	0.041
	3/16	0.13	0.16	0.336	0.095
	1/4	0.24	0.30	0.588	0.167
	5/16	0.37	0.46	0.923	0.261
	3/8	0.53	0.67	1.335	0.378
	1/2	0.95	1.19	2.350	0.665
	5/8	1.49	1.86	3.680	1.043
	3/4	2.15	2.68	5.300	1.502
	1	3.81	4.77	9.41	2.670

TABLE II
ELECTRODE REQUIREMENTS FOR VARIOUS TYPES OF WELDS
(Manual Welding)

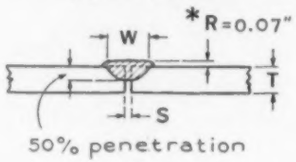
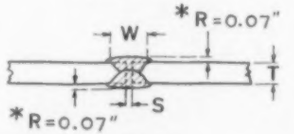
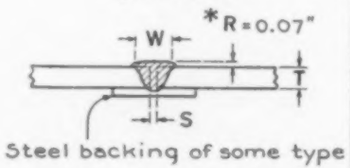
TYPE OF WELD	INCHES			WEIGHT OF ELECTRODES REQUIRED IN POUNDS PER LINEAR FOOT (Approx)				AMOUNT OF STEEL DEPOSITED PER LINEAR FOOT			
				WITHOUT REINFORCEMENT		* WITH REINFORCEMENT		WITHOUT REINFORCEMENT		* WITH REINFORCEMENT	
	T	W	S	Bare and Thinly Coated	Heavily Coated	Bare and Thinly Coated	Heavily Coated	Cu In.	Pounds	Cu In.	Pounds
SQUARE GROOVE  Fig. 4	3/16	3/8	0	—	—	0.13	0.16	—	—	0.312	0.088
			1/16	0.03	0.04	0.16	0.20	0.071	0.020	0.384	0.109
	1/4	1/8	1/32	0.04	0.05	0.19	0.23	0.094	0.027	0.415	0.129
			3/32	0.06	0.07	0.20	0.26	0.140	0.039	0.504	0.143
	5/16	1/2	1/32	0.05	0.06	0.22	0.27	0.118	0.033	0.540	0.153
			3/32	0.07	0.09	0.24	0.30	0.176	0.050	0.600	0.170
SQUARE GROOVE  Fig. 5	3/16	3/4	0	—	—	0.17	0.21	—	—	0.42	0.119
			3/32	0.02	0.03	0.19	0.24	0.047	0.013	0.467	0.132
	1/4	3/8	3/32	0.03	0.04	0.28	0.36	0.071	0.020	0.70	0.199
			1/16	0.06	0.07	0.31	0.39	0.141	0.040	0.77	0.218
	1/4	1/4	1/16	0.08	0.10	0.37	0.47	0.188	0.053	0.92	0.261
			3/32	0.12	0.14	0.43	0.53	0.282	0.080	1.02	0.288
If underside of top weld is chipped or burned out and welded, add 0.07 lb to steel deposited (equivalent to approx 0.10 lb of thinly coated or 0.13 lb of heavily coated electrodes.)											
SQUARE GROOVE  Fig. 6	1/8	1/4	0	—	—	0.09	0.11	—	—	0.210	0.060
			1/16	0.04	0.05	0.12	0.15	0.094	0.027	0.304	0.086
	1/4	3/8	1/16	0.06	0.07	0.18	0.23	0.140	0.040	0.456	0.129
			3/32	0.09	0.11	0.21	0.27	0.211	0.060	0.526	0.149
	1/4	1/4	1/32	0.12	0.14	0.26	0.33	0.282	0.080	0.649	0.184
			1/8	0.15	0.19	0.30	0.38	0.376	0.107	0.742	0.210

TABLE III
ELECTRODE REQUIREMENTS FOR VARIOUS TYPES OF WELDS
(Manual Welding)

TYPE OF WELD	INCHES			WEIGHT OF ELECTRODES REQUIRED IN POUNDS PER LINEAR FOOT (Approx)				AMOUNT OF STEEL DEPOSITED PER LINEAR FOOT			
				WITHOUT REINFORCEMENT		* WITH REINFORCEMENT		WITHOUT REINFORCEMENT		* WITH REINFORCEMENT	
	T	W	S	Bare and Thinly Coated	Heavily Coated	Bare and Thinly Coated	Heavily Coated	Cu In.	Pounds	Cu In.	Pounds
"V" GROOVE	1/4	0.405		0.33	0.41	0.49	0.61	0.815	0.231	1.200	0.340
	5/16	0.476		0.46	0.58	0.65	0.81	1.14	0.323	1.595	0.452
	3/8	0.549		0.62	0.77	0.83	1.03	1.521	0.432	2.04	0.577
	1/2	0.693		1.00	1.25	1.26	1.58	2.460	0.696	3.12	0.882
	5/8	0.838		1.46	1.82	1.78	2.23	3.600	1.020	4.40	1.248
	3/4	0.982		2.00	2.50	2.39	3.00	4.960	1.405	5.91	1.675
	1	1.273		3.40	4.23	3.87	4.83	8.350	2.370	9.57	2.710
"V" GROOVE	1/4	0.207	1/16	0.12	0.15	0.20	0.25	0.300	0.085	0.504	0.143
	5/16	0.311	3/32	0.25	0.31	0.37	0.46	0.611	0.173	0.911	0.258
	3/8	0.414	1/8	0.40	0.50	0.56	0.70	0.995	0.282	1.390	0.394
	1/2	0.558	1/8	0.70	0.87	0.91	1.15	1.730	0.489	2.263	0.641
	5/8	0.702	1/8	1.08	1.35	1.35	1.68	2.660	0.753	3.330	0.942
	3/4	0.847	1/8	1.55	1.94	1.88	2.35	3.840	1.088	4.650	1.320
	1	1.138	1/8	2.76	3.45	3.20	4.00	6.810	1.930	7.90	2.240
"V" GROOVE	1/4	0.207	1/16	——	——	0.32	0.41	——	——	0.815	0.231
	5/16	0.311	3/32	——	——	0.49	0.62	——	——	1.225	0.346
	3/8	0.414	1/8	——	——	0.68	0.85	——	——	1.680	0.475
	1/2	0.558	1/8	——	——	1.16	1.45	——	——	2.870	0.811
	5/8	0.702	1/8	——	——	1.59	1.99	——	——	3.940	1.115
	3/4	0.847	1/8	——	——	2.13	2.66	——	——	5.250	1.490
	1	1.138	1/8	——	——	3.44	4.30	——	——	8.500	2.410

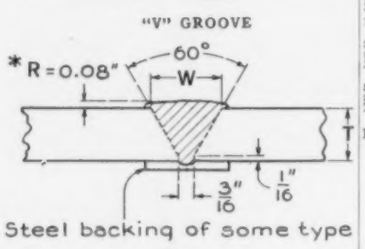


Fig. 7

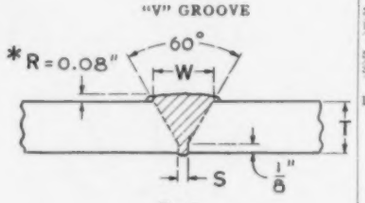


Fig. 8

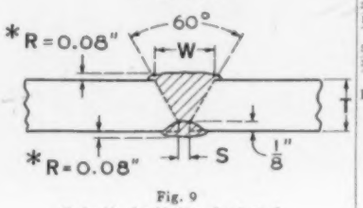


Fig. 9
Underside of weld chipped or burned out and welded.

TABLE IV
ELECTRODE REQUIREMENTS FOR VARIOUS TYPES OF WELDS
(Manual Welding)

TYPE OF WELD	INCHES		WEIGHT OF ELECTRODES REQUIRED IN POUNDS PER LINEAR FOOT (Approx)				AMOUNT OF STEEL DEPOSITED PER LINEAR FOOT			
			WITHOUT REINFORCEMENT		* WITH REINFORCEMENT		WITHOUT REINFORCEMENT		* WITH REINFORCEMENT	
	T	W	Bare and Thinly Coated	Heavily Coated	Bare and Thinly Coated	Heavily Coated	Cu In.	Pounds	Cu In.	Pounds
DOUBLE "V" GROOVE	5/8	0.405	0.72	0.90	1.03	1.29	1.775	0.502	2.56	0.724
	3/4	0.468	0.98	1.22	1.34	1.68	2.410	0.682	3.31	0.937
	1	0.630	1.68	2.10	2.17	2.71	4.150	1.175	5.36	1.520
	1 1/4	0.774	2.53	3.17	3.13	3.92	6.27	1.775	7.75	2.195
	1 1/2	0.919	3.56	4.45	4.28	5.35	8.85	2.495	10.59	3.00
	1 3/4	1.063	4.77	5.95	5.58	6.98	11.80	3.335	13.82	3.91
	2	1.207	6.13	7.68	7.10	8.88	15.20	4.30	17.58	4.97
	2 1/4	1.352	7.70	9.60	8.75	10.95	19.00	5.38	21.65	6.12
	2 1/2	1.496	9.43	11.80	10.60	13.20	23.30	6.60	26.20	7.40
	3	1.784	13.36	16.70	14.75	18.50	33.00	9.35	36.50	10.33
	3 1/2	2.073	18.10	22.60	19.70	24.60	44.70	12.65	48.70	13.80
	4	2.368	23.50	29.40	25.40	31.70	58.15	16.45	62.80	17.80

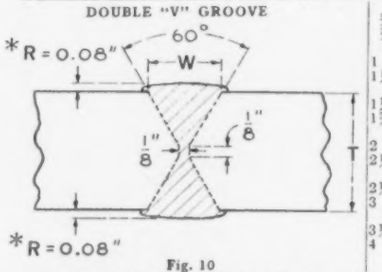


Fig. 10
If underside of top weld is chipped or burned out and welded, add 0.10 lb to steel deposited (equivalent to approx 0.14 lb thinly coated or 0.18 lb of heavily coated electrodes.)

"U" GROOVE	1/2	0.652		1.18		1.49	2.325	0.659	2.95	0.835
	5/8	0.705		1.70		2.04	3.345	0.947	4.02	1.140
	3/4	0.758		2.24		2.61	4.435	1.255	5.17	1.465
	1	0.865		3.47		3.89	6.870	1.945	7.70	2.180
	1 1/4	0.971		4.86		5.35	9.62	2.72	10.60	3.00
	1 1/2	1.077		*6.41		6.95	12.66	3.59	13.72	3.89
	1 3/4	1.173		8.08		8.65	16.00	4.53	17.10	4.84
	2	1.292		10.00		10.65	19.75	5.60	21.04	5.96
	2 1/4	1.396		12.05		12.75	23.80	6.75	25.20	7.12
	2 1/2	1.502		14.25		15.00	28.20	7.98	29.65	8.40
	2 3/4	1.608		16.60		17.40	32.80	9.29	34.65	9.73
	3	1.715		19.10		20.00	37.80	10.70	39.45	11.19
	3 1/2	1.927		24.70		25.50	48.60	13.80	50.50	14.30
	4	2.140		30.90		31.90	61.00	17.30	63.10	17.90

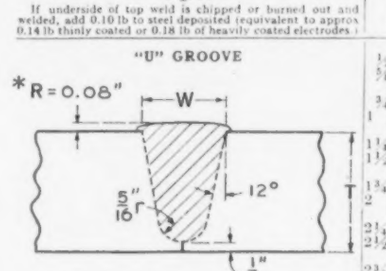


Fig. 11
If underside of weld is chipped or burned out and welded, add 0.19 lb to steel deposited (equivalent to approx 0.27 lb of thinly coated or 0.34 lb of heavily coated electrodes).

MODIFIED "U" GROOVE	1/2									
	5/8									
	3/4									
	1									
	1 1/4									
	1 1/2									
	1 3/4									
	2									
	2 1/4									
	2 1/2									
	2 3/4									
	3									
	3 1/2									
	4									

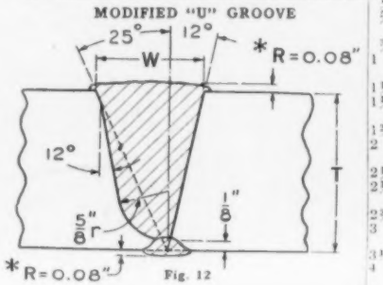


Fig. 12

For irregular shapes, preparation of the modified "U" groove is usually more economical than the regular "U" groove (Fig. 11).

Approx 5 per cent more electrode must be used to fill the joint than for the regular "U" groove.

TABLE V
ELECTRODE REQUIREMENTS FOR VARIOUS TYPES OF WELDS

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(Manual Welding)

TYPE OF WELD	INCHES		WEIGHT OF ELECTRODES REQUIRED IN POUNDS PER LINEAR FOOT (Approx)				AMOUNT OF STEEL DEPOSITED PER LINEAR FOOT			
			WITHOUT REINFORCEMENT		* WITH REINFORCEMENT		WITHOUT REINFORCEMENT		* WITH REINFORCEMENT	
	T	W	Bare and Thinly Coated	Heavily Coated	Bare and Thinly Coated	Heavily Coated	Cu In.	Pounds	Cu In.	Pounds
DOUBLE "U"	1	0.685	.....	2.86	.....	3.54	5.64	1.60	6.96	1.98
	1¼	0.731	.....	3.91	.....	4.62	7.75	2.19	9.15	2.59
	1½	0.784	.....	5.05	.....	5.83	10.00	2.83	11.55	3.27
	1¾	0.838	.....	6.30	.....	7.12	12.47	3.53	14.10	3.99
	2	0.891	.....	7.60	.....	8.46	15.08	4.26	16.74	4.74
	2¼	0.944	.....	9.00	.....	9.90	17.80	5.04	19.60	5.55
	2½	0.997	.....	10.45	.....	11.45	20.70	5.85	22.60	6.41
	2¾	1.050	.....	12.00	.....	13.05	23.80	6.73	25.80	7.30
	3	1.103	.....	13.85	.....	14.90	27.15	7.75	29.40	8.34
	3½	1.211	.....	17.20	.....	18.40	33.98	9.61	36.30	10.30
	4	1.316	...	21.00	...	22.30	41.55	11.75	44.00	12.50

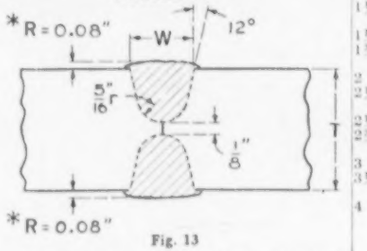


Fig. 13

If underside of top weld is chipped or burned out and welded, add 0.19 lb to steel deposited (equivalent to approx 0.27 lb of thinly coated or 0.34 lb of heavily coated electrodes).

BEVEL GROOVE	⅛	0.125	0.04	0.05	0.08	0.10	0.096	0.027	0.216	0.061
	¼	0.188	0.09	0.11	0.16	0.20	0.216	0.061	0.396	0.112
	⅜	0.250	0.15	0.19	0.25	0.31	0.372	0.106	0.611	0.173
	½	0.375	0.34	0.43	0.49	0.61	0.840	0.238	1.211	0.343
	⅝	0.500	0.61	0.76	0.80	1.00	1.500	0.425	1.980	0.560
	¾	0.625	0.95	1.19	1.19	1.50	2.340	0.663	2.950	0.835
	1	0.875	1.86	2.33	2.25	2.81	4.590	1.303	5.57	1.575

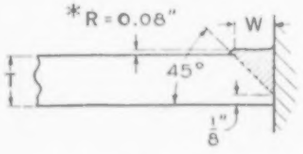


Fig. 14

If underside of weld is chipped or burned out and welded, add 0.19 lb to steel required (equivalent to approx 0.27 lb thinly coated or 0.34 lb of heavily coated electrodes).

DOUBLE-BEVEL GROOVE	½	0.188	0.17	0.22	0.32	0.39	0.42	0.120	0.78	0.221
	⅝	0.250	0.30	0.38	0.50	0.62	0.756	0.213	1.238	0.350
	¾	0.313	0.48	0.59	0.72	0.90	1.175	0.332	1.775	0.503
	1	0.438	0.93	1.16	1.27	1.58	2.294	0.648	3.130	0.886
	1¼	0.563	1.54	1.92	1.97	2.46	3.790	1.076	4.870	1.38
	1½	0.688	2.30	2.87	2.83	3.54	5.670	1.607	7.00	1.98
	1¾	0.813	3.21	4.01	3.83	4.78	7.92	2.245	9.47	2.68
	2	0.938	4.27	5.33	5.00	6.25	10.53	2.985	12.33	3.50

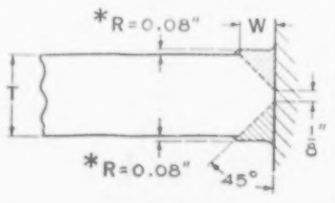


Fig. 15

If underside of top weld is chipped or burned out and welded, add 0.19 lb to steel required (equivalent to approx 0.27 lb thinly coated or 0.34 lb of heavily coated electrodes).

TABLE VI

ELECTRODE REQUIREMENTS FOR VARIOUS TYPES OF WELDS

(Manual Welding)

TYPE OF WELD	INCHES		WEIGHT OF ELECTRODES REQUIRED IN POUNDS PER LINEAR FOOT (Approx)				AMOUNT OF STEEL DEPOSITED PER LINEAR FOOT			
			WITHOUT REINFORCEMENT		* WITH REINFORCEMENT		WITHOUT REINFORCEMENT		* WITH REINFORCEMENT	
	T	W	Bare and Thinly Coated	Heavily Coated	Bare and Thinly Coated	Heavily Coated	Cu In.	Pounds	Cu In.	Pounds
"J" GROOVE	1	0.625	.....	2.55	.....	2.85	5.03	1.43	5.64	1.60
	1¼	0.719	.....	3.64	.....	4.00	7.20	2.04	7.91	2.24
	1⅝	0.781	.....	4.80	.....	5.15	9.46	2.69	10.20	2.89
	1¾	0.875	.....	6.12	.....	6.55	12.12	3.43	12.95	3.67
	2	0.969	.....	7.40	.....	7.87	14.63	4.15	15.60	4.41
	2¼	1.031	.....	9.00	.....	9.42	17.75	5.03	18.35	5.19
	2⅝	1.094	.....	10.60	.....	11.10	20.90	5.92	21.95	6.21
	2¾	1.188	.....	12.30	.....	12.92	24.35	6.90	25.55	7.23
	3	1.281	.....	14.20	.....	14.80	28.10	7.95	29.30	8.29
	3½	1.438	.....	18.40	.....	19.10	36.30	10.30	37.80	10.70
	4	1.594	.....	23.00	.....	23.70	45.40	12.90	47.00	13.30

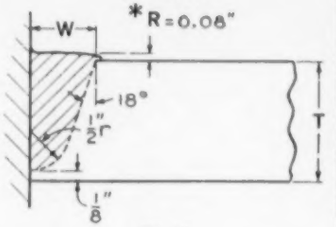


Fig. 16

If underside of weld is chipped or burned out and welded, add 0.19 lb to steel required (equivalent to approx 0.27 lb thinly coated or 0.34 lb of heavily coated electrodes).

DOUBLE-"J" GROOVE	1	0.500	.....	1.87	.....	2.37	3.71	1.05	4.67	1.33
	1¼	0.563	.....	2.48	.....	3.03	4.92	1.39	6.00	1.70
	1⅝	0.594	.....	3.52	.....	4.08	6.95	1.97	8.10	2.29
	1¾	0.625	.....	4.37	.....	5.00	8.635	2.45	9.83	2.79
	2	0.656	.....	5.47	.....	6.11	10.80	3.06	12.06	3.42
	2¼	0.688	.....	6.55	.....	7.21	12.97	3.67	14.29	4.04
	2½	0.750	.....	7.65	.....	8.38	15.12	4.28	16.68	4.69
	2¾	0.781	.....	8.85	.....	9.60	17.52	4.95	19.00	5.38
	3	0.813	.....	10.10	.....	10.85	19.82	5.62	21.45	6.08
	3½	0.906	.....	12.70	.....	13.55	25.05	7.12	26.80	7.58
	4	0.969	.....	15.70	.....	16.60	31.05	8.78	32.80	9.28

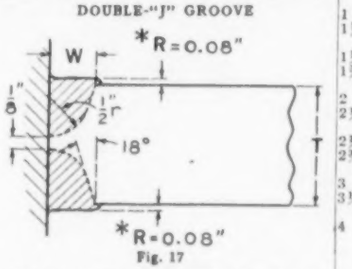


Fig. 17

If underside of top weld is chipped or burned out and welded, add 0.19 lb to steel required (equivalent to approx 0.27 lb thinly coated or 0.34 lb of heavily coated electrodes).

STRUCTURAL FABRICATION BY Welding*

By C. E. LOOS†

STRUCTURAL FABRICATION BY WELDING

THE successful application of welding in the fabrication of structural steel depends as much upon the designer's knowledge of welding design, processes, technique and fabricating methods as it does upon the fabricator's skill, equipment and ingenuity.

Welding cannot gain recognition as a structural fabricating method unless the completely welded assembly is safe and either lower in cost than a competitive type of structure or possesses advantages not attainable by other methods of fabrication. It is not an uncommon experience to find welded joints of questionable strength, costly details that require too much preparation and welding, and designs that fail to take full advantage of the opportunities for originality and saving offered by this new process.

Riveting standards have been used and developed over a period of years, so that they are now applied without a great deal of speculation as to safety and cost. Welding on the other hand, is still in the development stage and each new type of joint must be carefully considered for strength and economy. The AMERICAN WELDING SOCIETY and other technical groups, as well as individual fabricators, are working hard to establish welding standards.

Some specifications impose restrictions that do not conform to good welding practice, but there are others being written today that are attempting to cover fully good welding design and workmanship in a sort of text-book fashion. They really contain good reliable information and should be read and followed by designing engineers and fabricators. The American Welding Society's Bridge Specification is one, and another in the process of writing is the tentative U.S. Navy Bureau of Yards and Docks Specification.

When considering a large project, on which there is likely to be a great deal of duplication, the first thing that must be decided upon is the welding method to be employed. The selection of the process may be governed by specifications, the type of work, equipment available or the time allowed for delivery. It may be found that fixtures and manipulators can be used to advantage. The type of joint that will ultimately be used may be dependent upon the welding process or the position in which the work can be welded.

The manually operated metallic arc welding process is the most commonly used. Structural engineers should, however, familiarize themselves with the various special present-day processes, such as the automatic metallic arc, the carbon arc and the Unionmelt process. They all have their advantages and limitations. The automatic welding process is very little used in structural shops, principally because of the lack of sufficient duplication in structural work.

Where there is large duplication and jigs and fixtures can be used, a saving is quite obvious. For a small number of parts, say eight or ten, the economy will depend somewhat upon the cost of the jig. Jigs are sometimes absolutely necessary to insure proper workmanship regardless of their cost. Welding manipulators for positioning welds are also valuable as a means for increasing the speed and distributing the heat of welding. Their

† American Bridge Company, Ambridge, Pa.

* Presented before a Joint Meeting of the New York Section, AMERICAN WELDING SOCIETY, and Metropolitan Section, American Society of Civil Engineers, New York, November 16, 1938.

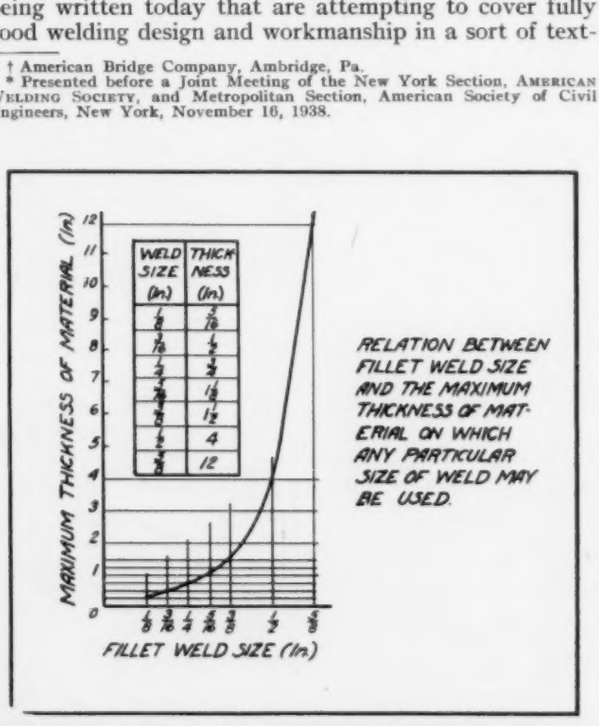

MAXIMUM THICKNESS OF MATERIAL (In.)
FILLET WELD SIZE (In.)
WELD SIZE (In.)
THICKNESS (In.)
RELATION BETWEEN FILLET WELD SIZE AND THE MAXIMUM THICKNESS OF MATERIAL ON WHICH ANY PARTICULAR SIZE OF WELD MAY BE USED.

Fig. 1—Relation between Fillet Weld Size and the Maximum Thickness on Which Any Particular Size of Weld May Be Used

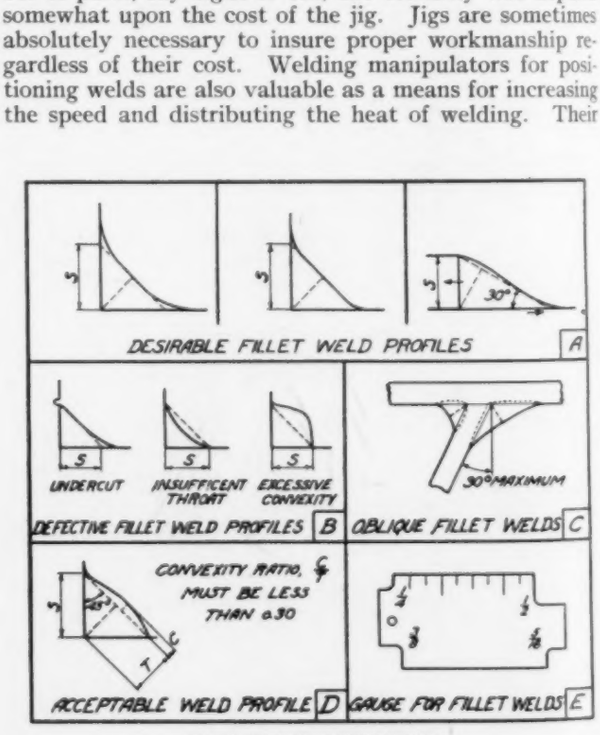


Fig. 2—Details of Fillet Welds

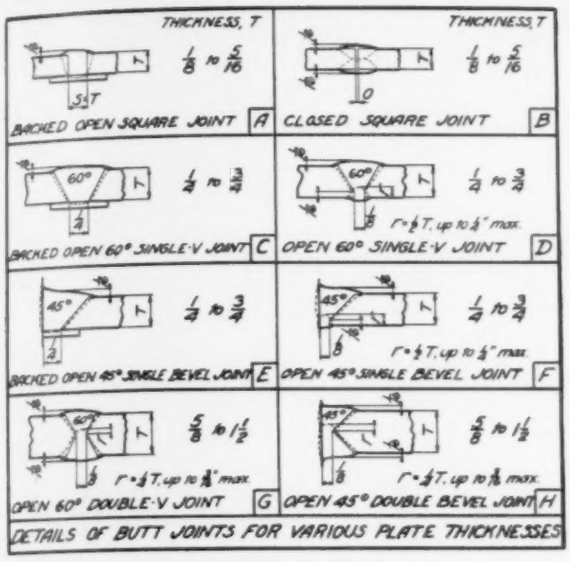

THICKNESS, T
1/8 to 5/16
BACKED OPEN SQUARE JOINT A
CLOSED SQUARE JOINT B
60°
1/4 to 3/4
BACKED OPEN 60° SINGLE-V JOINT C
OPEN 60° SINGLE-V JOINT D
45°
BACKED OPEN 45° SINGLE BEVEL JOINT E
OPEN 45° SINGLE BEVEL JOINT F
5/8 to 1 1/2
OPEN 60° DOUBLE-V JOINT G
OPEN 45° DOUBLE BEVEL JOINT H
DETAILS OF BUTT JOINTS FOR VARIOUS PLATE THICKNESSES

Fig. 3—Butt Weld Details

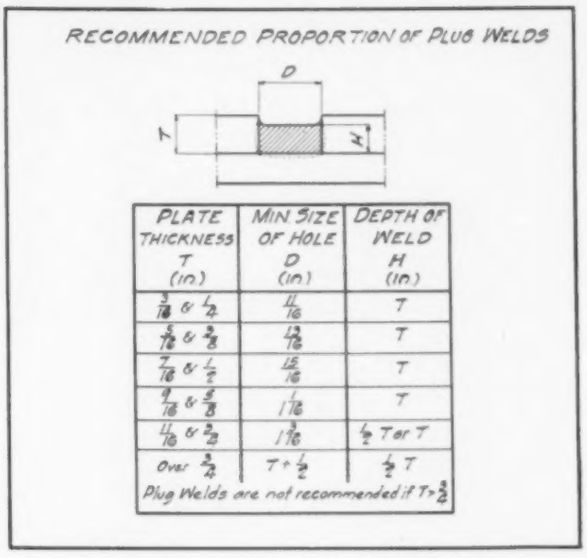


PLATE THICKNESS T (in.)	MIN SIZE OF HOLE D (in.)	DEPTH OF WELD H (in.)
3/16 & 1/4	11/16	T
5/16 & 3/8	13/16	T
7/16 & 1/2	15/16	T
9/16 & 5/8	1 1/16	T
11/16 & 3/4	1 3/16	1/2 T or T
Over 3/4	T + 1/2	1/2 T

Plug Welds are not recommended if T > 3/4

Fig. 4—Recommended Proportions for Plug Welds

use will depend upon their cost and the volume of work to be handled. These devices range from simple rollers, such as are used for rotating pipe, to the more elaborate motor driven tilting tables.

Types of Welds

The type and amount of weld required will depend upon a proper stress analysis of each joint and upon the unit stresses permitted by the specifications. If any doubt exists relative to the merits and economy of alternate types of joints, a few simple tests may be devised to settle the point in question.

Where the material is relatively thick, it is sometimes necessary to specify a larger fillet weld than is theoretically required, because of the rapid dissipation of heat with a chilling effect and likelihood of cracks occurring when the weld is too small. The recommended minimum fillet weld sizes for various thicknesses of material are shown in Fig. 1.

Structural shops are usually concerned with only three types of welds, namely, the fillet, butt and plug weld. The fillet weld is the most commonly used in structural work because it is the most adaptable for use with shapes, and requires the least amount of preparation of material and welding.

Figure 2 shows the proper form for fillet welds and also some of the irregularities found in practice. There is also shown a simple form of gage for checking the size of the fillet.

Figure 3 shows the common forms of butt welds. The butt weld is the most desirable for transmission of stresses and for fatigue resistance. It is also capable of developing high shrinkage stresses. If no backing is provided, the root of the butt weld must be chipped out and rewelded from the root side.

Figure 4 shows a tentative recommendation for size of plug welds in relation to the thickness of material. Plug welds have many applications and are especially useful in repair and reinforcing work. It is believed that future specifications will be more liberal in permitting their use as stress carriers. The American Bridge Company now has a series of plug weld tests under way to determine the strength of such welds for holes of different sizes punched, drilled, flame-cut and countersunk in material of different thicknesses.

The use of a uniform and standard method for indicating welds on drawings is essential. The American Bridge Company has adopted the AMERICAN WELDING SOCIETY'S symbols and finds them to be very satisfactory.

As the final step in preparing his drawings for the shop, the engineer must give careful consideration to mill overruns in the material and make suitable allowance for them where necessary. Proper allowance for finishing is also essential, since accuracy in fitting plays an important rôle in fabrication by welding. Sufficient clearance should be provided for erection and the use of fillers avoided.

Qualification Tests

When the job reaches the shop, one of the first things to consider is the matter of qualifying the process and the welders in accordance with the customer's specification. This may seem a relatively unimportant matter, but it sometimes causes delay in starting work, and it may be quite costly. The writer is a firm believer in the qualification of welders and hopes that some day a simple inexpensive qualification test will be accepted by everyone concerned.

The welders' qualification test that is recommended costs less than $2.00 per specimen. It is a modification of the specimen used by the AMERICAN WELDING SOCIETY for qualifying the process and was illustrated in the April 1938 JOURNAL of the AMERICAN WELDING SOCIETY.

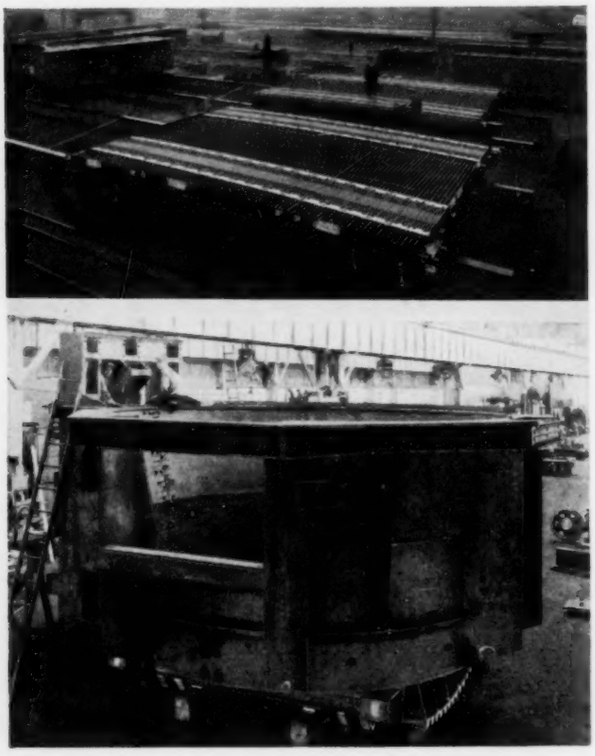
Welding Wire

A few engineers choose to designate by trade name the electrode required for use on their work. If it is not the type with which the welders are familiar, the quality of welds and speed of welding may be adversely affected. A grade 15 electrode is preferred and this heavily coated wire will produce deposited metal having a minimum strength of 60,000 pounds per square inch with an elongation in 2 inches of 17 per cent or greater. It is commonly designated as a general purpose electrode suitable for poor fit-up.

Preparation of Material

The preparation of the materials for welding is an item that is given careful consideration by the shop. Time and money spent for planing or machine flame cutting to

Welded Expansion Joint Assembly—Manhattan Bridge, N. Y.



Welded Shell for Type 25 Heroult Electric Furnace

insure accurate fit-up may be saved over and over again in reduced fitting and welding costs. Sheared or rolled edges, such as the toes of angles, are often totally unsatisfactory for assembly or welding. Flame-cutting machines as well as high-speed saws, are valuable tools in the preparation of material for welding. There is no objection to welding on flame-cut surfaces, provided that all loose scale is removed. If the material is sheared, the shear blades should be set to give a square and clean cut. The material must be carefully straightened to insure contact with joining members. It is sometimes advisable to order plates with special tolerances for flatness. Templets are provided for detail material as in riveting.

Assembly

Following the preparation of the material is the assembly of the parts. This is really the most important operation in shop weld fabrication. The fitter must devise means for aligning the parts and for temporarily holding them securely together. It may sometimes be necessary to force the parts into contact or alignment by making use of wedges, wooden struts, weights or even ratchets. The component parts of a member are usually fitted and welded separately whenever it is possible.

The work is laid out upon level assembly skids, tables or floors. Working points very often fall outside of the structure and the fitter must in such cases follow a full size layout on the working table or construct a templet. He thus performs the duties of a layer-out as well as those of a fitter.

Where jigs or fixtures are used, the work may be tack welded in the jig and then removed for final welding in another location. It is sometimes necessary, however, that the assembly be welded complete in the jig.

The fitter must anticipate the amount of warpage and shrinkage that is likely to occur in welding the part and, if possible, compensate for such deformations when assembling the member. In correcting for warpage it is at times customary to put a camber in the piece in the direction opposite to that in which warpage is likely to occur.

The member will usually shorten on the side where the greatest amount of heat has been applied. There are no mathematical rules for calculating the amount of warpage or shrinkage that is likely to occur. The corrections made are based solely upon experience. Shrinkage will sometimes amount to as much as $^1/_{16}$ inch in 10 feet. This quantity will vary with the amount of welding and it may not always be the same for identical structures. If the member is to be finished to length, correction for shrinkage may be made when fitting the end connecting details. Where proper allowance has not been made to compensate for shrinkage, it has sometimes been found necessary to add pads of weld metal to the ends. This is not a very desirable or economical practice.

The tack welder working with the fitter should be a qualified welder. The tack weld should be of good quality, if the finished weld is to be made over it, otherwise it should be chipped out before the final weld is made. This is a detail often overlooked.

Shop Welding

In the welding operation itself one of the first matters to consider is the type and size of electrode to be used. This varies somewhat with the character of the work and the skill of the operator. It may also be controlled by the specifications. The sizes most generally used in structural shops are $^3/_{16}$ inch, $^7/_{32}$ and $^1/_4$ inch for flat and horizontal welds and $^5/_{32}$ inch for vertical and overhead. It is very essential in making fillet welds that the welder obtain full penetration at the root of the fillet and this fact should not be overlooked when selecting the size of electrode. It is equally important that the weld be of the specified size with no undercutting of the parent metal. It is also desirable at times to use a large electrode with a correspondingly high current to get sufficient heat into the material and thus prevent quick chilling of the weld metal. In the interests of speed and economy the fabricator will always use the largest diameter of electrode consistent with good welding practice.

In laying fillet welds the cost may be kept to a minimum if the welder can complete the weld in one pass. It is believed that a $^5/_{16}$-inch fillet is the largest one-pass fillet weld that can be made economically and it may be safely used on materials up to $1^1/_8$-inches thick. Beyond that thickness the larger sizes must be used, as was shown on the table for minimum fillet weld sizes.

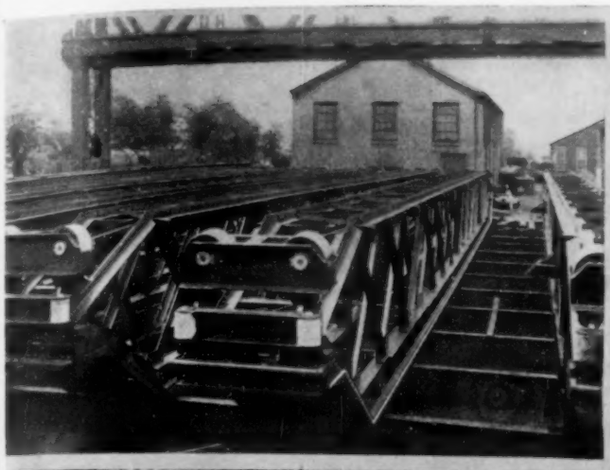
Where fit-up is poor and there is a gap of from $^1/_{32}$ inch to $^1/_8$ inch between the parts, it is essential that the fillet size be increased over that specified to compensate for the opening. Wide openings in joints should be avoided where possible, for the welder in order to bridge the gap will tend to choke his arc to as small a length as possible and will in all probability entrap slag in the deposited metal.

The welder's production is gaged by the number of stub ends of electrode that he turns in at the end of each day's work. Welding costs and production records are based primarily upon the weight of electrode consumed and wasted and not upon the footage of different size welds.

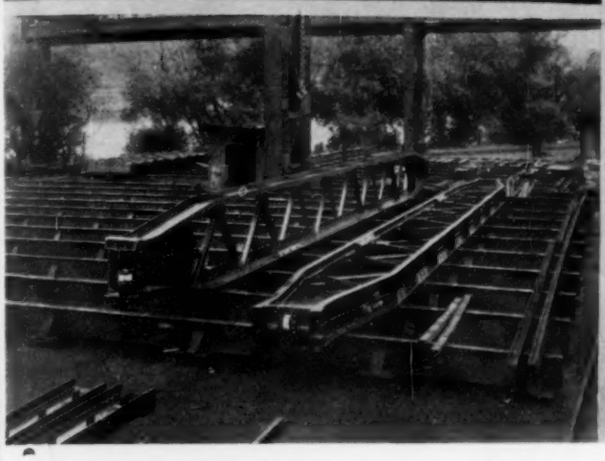
Distortion

The sequence of welding is an important factor to be observed in preventing either distortion or locked-up stresses. It is the usual practice to weld from the center toward the ends of a member or distribute the welds so

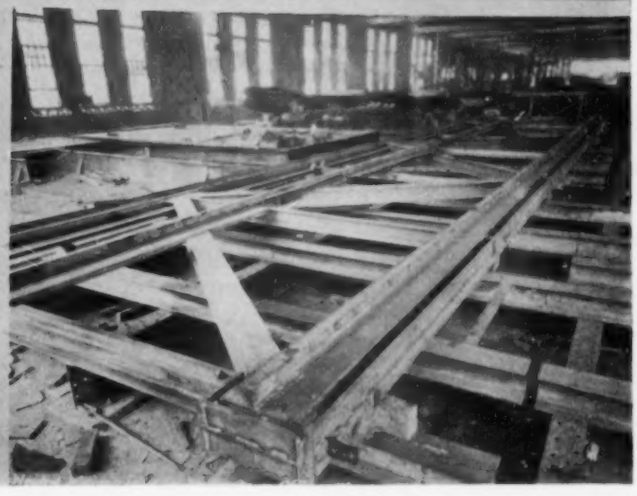
Welded Emergency Bulkhead Girders for Roller Gates—Mississippi River Dam #25



Welded Cargo Barge—Campbell Transportation Company



Welded Emergency Bulkhead Girders for Tainter Gates—Mississippi River Dam #25



Welded Warren Truss for Westinghouse Office & Warehouse Building, Mansfield, Ohio

that the heat of welding is not localized in any one section. Butt welds should not be made between two members where both ends are restrained. This, most surely, will result in a cracked or a highly internally stressed weld. There are instances where this cannot be avoided, as in the repair or reinforcing of existing structures, and here the use of peening may be employed to advantage in order to cause a plastic flow of the weld metal and thus relieve internal stress. The use of peening is not generally recommended because the weld metal is likely to be abused, if careful supervision is not exercised.

Furnace stress relieving by heating the completely welded member to from 1100 to 1200° F. is not practicable for the general run of structural members nor is it considered necessary for this class of work. The heating of such assemblies would result in unpredictable distortion due to relieving the residual stresses produced at the rolling mill.

In spite of all the precautions that may be taken by the fitters and welders, distortion cannot always be eliminated. That which remains must be taken care of mechanically or by the application of heat to the convex side of the member. The engineer can do more to prevent distortion than the fabricator, if he will but design or detail his members where possible so that the amount of welding is placed symmetrically about the center of gravity of the member.

Inspection

Welding supervision and inspection is a phase of shop fabrication that should not be overlooked, if a high quality of workmanship is to be maintained. While it is impossible for an inspector to witness every inch of welding as it is being deposited, he can, however, observe some of it and can detect evidence of faulty workmanship from an inspection of the finished weld. Welds that are undersize may be reinforced with additional weld metal and those that are defective must be chipped out and rewelded. If the welds are to be water- or oil-tight, caulking should not be permitted. Welds should be inspected for size, length, spacing, cracks, overlaps, undercuts and excessive convexity and concavity. The location of the crater with respect to the functioning of the weld when in service is also a matter for the inspector's attention. The welder's identifying stamp should be noted, for it has often been observed that where the weld is poor this stenciling has been omitted. Non-destructive methods of weld inspection, notably the magnetic methods, are being used in some shops with apparent success.

Temperature

The question of temperature, below which welding should not be permitted, is a much debated one. Existing specifications set this minimum temperature limit

anywhere from 32 to 10° F., yet there are fabricators and erectors that claim to have successfully welded structures at temperatures far below these limits. It is not known what the initial stresses were in these welds, but the fact remains that the structures are still standing. It is believed that the limiting temperature depends a great deal upon the character of the work and particularly upon the thickness of the material. Relatively thick material in proportion to weld size cannot be welded at as low a temperature as thinner material. The writer believes that a limit of 20° F. would be safe for the general run of 0.25 per cent carbon steel structural work.

Cleaning

The cleaning of welds is a shop operation that must be given some consideration from a cost standpoint. One of the requirements in choosing an electrode is the ease with which the slag may be removed from the surface of the weld. While most of the slag drops off very readily, there is always some that clings tenaciously to the edges of the welds. It is this slag that causes trouble when the material is to be galvanized. If there is a group of welders working in one vicinity, it may be advantageous to have a helper with a pneumatic scaler clean the welds for the entire group. There is some advantage, however, in having the welder clean his own welds, since he then has an opportunity to inspect them and correct defects.

Safety

It is a wise shop policy to keep welding equipment in good condition; to use welding machines of ample capacity and to protect the welders against health hazards. The helmet should be sealed properly to protect the welder's eyes and the clear cover glasses should be changed as frequently as necessary to insure good vision. When working in confined places, proper ventilation should be provided.

Painting

Paint is usually omitted from parts adjacent to the point where welds are to be made, because it is detrimental to good welding and the fumes created from burning paint may cause the welder to become ill. A shop coat of linseed oil is sometimes specified, but from the quality of weld standpoint it would be better if it were not applied at all, unless the material is to be placed in storage for some length of time or exported.

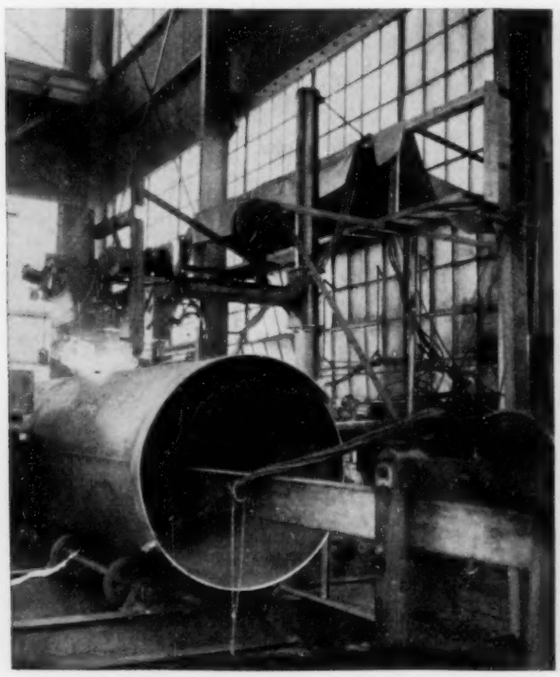
Field Erection

In field erection the selection of qualified welders again becomes a problem, for here the welder must have ability to climb and weld in high and awkward positions. He will probably be called upon to do more vertical and overhead welding than the shop welder. If the erector can employ welders continuously, there should be no trouble in developing a force of good welders, but if he must depend upon floaters, he will have difficulty in finding capable qualified men.

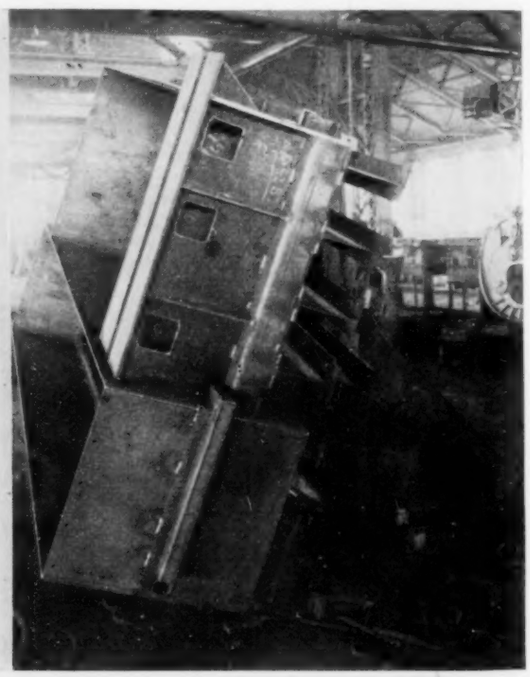
The number of field welds should be reduced to a minimum. Sketches covering the welding details of each type of field connection should be provided for the erector.

The designer or detailer should endeavor to have his welds located so that they are easily accessible for the welder. He should also give preference for position of welding in the following order—flat, horizontal, vertical and overhead for fillet welds and flat, vertical, overhead and horizontal for butt welds. This is not important where the work can be positioned to eliminate vertical and overhead welds.

Bolting is the most commonly used and logical means for holding the material in place during erection. The bolts are sometimes removed after the welding has been completed, but they are generally left in place. Other means for holding the assembly in position have been used, but the use of such temporary connections may be restricted by codes. The welders are usually able to keep pace with other erecting operations.



Welding Gas Mains by Carbon Arc Method



Tin Pot Shell on a Welding Manipulator

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ANNUAL MEETING

All members having suggestions for papers for Annual Meeting of the AMERICAN WELDING SOCIETY to be held in Chicago during the week of October 22nd should send in these suggestions at once to the Society so that they may be considered by the National Program Committee.

Welding Society
ACTIVITIES—Related Events

A MESSAGE TO MEMBERS OF AMERICAN WELDING SOCIETY

The AMERICAN WELDING SOCIETY begins the year 1939 under auspicious circumstances. Its membership of 3665 is the largest in the history of the Society. It has some 40 active Sections. Its Handbook and Welding Journal have been accepted throughout the civilized world as authoritative sources of information in the welding field. Its codes, standards and specifications are widely used and accepted.

The increase in membership and number of Sections is due very largely to a group of public spirited manufacturing companies in supporting an expansion program. The new budget of the AMERICAN WELDING SOCIETY, recently approved by the Board of Directors, is conservative and designed so that the Society may operate within its regular income without supplementary direct contributions. We have every reason to believe that the welding industry wishes to see the technical and research work of the Society expanded and the JOURNAL maintain its present high standard or improved. The Society is seeking support for this enlarged program through the regular sources of revenue available to it, namely, advertising and Sustaining Memberships. This will leave the field of direct contributions open to the Welding Research Committee, the work of which the Society is justly proud.

At a meeting of the Executive Committee held in New York on January 12th the following program of technical activities was approved.

Program of Technical Activities American Welding Society

1. Promulgate codes, standards and specifications as may be needed in new industries as, for example, hydraulic piping, elevated storage tanks, and the like.
2. Revise existing codes keeping them up-to-date. These include bridges, buildings, machinery, marine construction, piping, etc.
3. Strive toward the attainment of simplification in code requirements and the elimination of duplicate codes in the same fields.
4. Simplify qualification requirements for processes, operators, materials and apparatus to the end that such qualification procedure may be less expensive and less restrictive to the use of welding without sacrifice of safety.
5. Assist in bringing about the adoption of A. W. S. codes or A. W. S. conference codes wherever possible; including use by other societies, regulatory bodies, municipalities, cities, states and the like.
6. Expedite as far as possible the work of all technical committees of the Society. Follow-up work, furnish guidance, stimulate progress and correlation.
7. Through properly appointed committees act as the technical spokesman at hearings, and conferences involving the technical side of welding. Supply technical information to members and visitors at A. W. S. office, by telephone and by letter. Act in an advisory capacity on technical matters to the committees of the Society, Outline of Work Committee, Executive Committee and Board of Directors.
8. Coordinate and conduct research in the science and art of welding, cooperating with industry, other societies, associations and governmental departments; make available in readily usable, condensed form the research knowledge existing in the literature of the world and cooperate with universities in the stimulation and coordination of welding research.

The appointment of an additional member of the staff—an Assistant Technical Secretary—was approved and will be named as soon as funds permit. The simplification of code requirements generally will receive a prominent place in this enlarged program.

H. C. BOARDMAN, *President*

1939 NOMINATING COMMITTEE

In accordance with the By-Laws President Boardman has appointed the following members to serve as the 1939 Nominating Committee:

P. G. Lang, Jr., *Chairman*, The Baltimore & Ohio Railroad, Baltimore, Md.

A. G. Oehler, Simmons-Boardman Pub. Co., 30 Church Street, New York City.

A. G. Bissell, Bureau of Construction & Repair, Navy Department, Washington, D. C.

D. H. Corey, The Detroit Edison Co., 2000 Second Avenue, Detroit, Mich.

R. S. Donald, Thomson-Gibb Electric Welding Co., 30 Church Street, New York City.

P. D. McElfish, Standard Oil Co., Box 1437, Arcade Station, Los Angeles, Calif.

J. A. Hall, Kansas City Structural Steel, Kansas City, Kansas.

This Nominating Committee is to select candidates for the following positions:

President—Term, one year.

First Vice-President—Term, one year.

Second Vice-President—Term, one year.

Four Directors-at-large.

The present incumbents in the offices to be filled at the next election are:

President: H. C. Boardman (Eligible for re-election to the same office).

First Vice-President: Col. G. F. Jenks (Not eligible to re-election having served two terms as First Vice-President).

Second Vice-President: T. C. Smith (Eligible to re-election).

Four Directors-at-large: Term 3 years, Ira T. Hook, G. A. Hughes, R. E. Kinkead, H. S. Smith, Andrew Vogel. (All eligible to re-election).

The purpose of announcing the appointment of the Nominating Committee in the JOURNAL is to provide every member of the AMERICAN WELDING SOCIETY an opportunity to write to one or more of these members of the Nominating Committee offering their suggestions.

The By-Laws provide that the Nominating Committee shall deliver to the Secretary in writing on or before the last Tuesday in May, the names of its nominees for the various elective offices next falling vacant, together with the written acceptance of each nominee. It is, therefore, desirable that suggestions be sent to the Nominating Committee sometime in February or early in March (preferably before March 15th).

WELDING LIBRARY

Several companies are making determined efforts to get a complete set of the bound volumes of the AMERICAN WELDING SOCIETY JOURNALS for their libraries. This is impossible because our supply of volumes for the years 1922 to 1929 inclusive and 1935 is exhausted. We still have available volumes of the following years: 1930, 1931, 1932, 1933, 1934, 1936, 1937, 1938.

The Society is now pressed for storage space. Because of this fact, for a short period (expiration date April 1, 1939), it is offering to sell to members only bound volumes in sets of eight volumes of above years at the price of $4.00 per volume, plus expressage. Each volume contains a subject and authors index.

In a recent patent search one company stated that information in these particular volumes was of tremendous help. The $4.00 figure quoted above is less than the average cost to the Society for the volume.

Please act promptly as our supply of the various volumes is quite limited.

AMERICAN WELDING SOCIETY
M. M. Kelly, *Secretary*

IN ITS OWN RANGE, EVERY

McKAY ELECTRODE

IS A CHAMPION

You will simplify your purchasing and your shop procedure if you make McKay Shielded-Arc Electrodes your standby for all welding uses. A world-famous independent research organization worked with the McKay laboratory staff in developing this line of technically correct and practically efficient welding rods. Each McKay Electrode has its own range of best performance and, taken all together, they cover all the requirements of advanced modern practice. Whatever the skill of your operator, he will lay on more uniform, sound, smooth, satisfactory welds with McKay Electrodes. Ask for a descriptive folder.

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ARC WELDING CONFERENCE PROCEEDINGS

The papers and discussions at the Third Kjellberg Arc Welding Conference held in Finsterwalde, Germany, in May 1938 have been issued in book form (200 pages) by Kjellberg Elektroden und Maschinen G.m.b.H. Eleven papers on the following topics are included in the book: ship repairs, portable automatic arc welders, automatic arc welding of boilers, bridge welding, welding of light metals, welded buses and railway cars, welded machinery, strength and ductility of welds, electrodes for structural steel, non-destructive testing and designing for welding.

A. M. BYERS CATALOG

The A. M. Byers Company, Pittsburgh, Pa., has issued a consolidated general catalog, complete as to standard specifications, dimensions and all such information essential to both the specifier and the purchaser. Copies may be obtained on request.

OKLAHOMA A. & M. COLLEGE ACTIVITIES

A group of students interested in the advancement of welding have arranged a program of activities. Plans are under way for possible affiliation of this group with the Oklahoma City Section of the AMERICAN WELDING SOCIETY.

Several meetings have been arranged. During November, Mr. H. Taylor presented a paper on Aircraft Welding. There was also a motion picture on Oxywelding in Production. Social features included a steak fry.

In December, Mr. Stephano, from Arabia, spoke on "Customs of the Arabs and Conditions of the Jews in Palestine."

During January, Mr. Paul See will present a paper on "Characteristics of the Welding Generators."

AN UNUSUAL HOBBY

F. F. Nichols of David City, Nebraska, is a welder and a good one. During the summer he has little time for hobbies but in the winter months, he takes a hand in some of the most unusual creative work of his own.

Turning away from repairing castings of massive proportions, Mr. Nichols takes up his oxyacetylene welding blowpipe, some steel welding rods and some bronze ones, a few additional light sheets of steel and sets to work fashioning small metal figures depicting life and action in the old West. These figurines have a vitality and vigor that might be found in the work of a craftsman of the Renaissance.

The solid body portions are built up with a melted steel rod and then given a lustrous coating of bronze with the bronze-welding rod. Exact blowpipe control of the direction of the intensely hot flame, and skillful manipulation of the welding rod makes possible the careful shaping of each figure. The patina, or surface color of the bronze coating, is obtained by varying the flame to get different effects of shading.

Figures in Mr. Nichols' composite groups are made up separately. For instance, in mounted groups the horsemen, saddles and horses are welded to shape separately, and then joined together by welding.

As can be seen, Mr. Nichols is inspired by scenes from the colorful old West that is vanishing so rapidly from our modern

Fig. 1—The Welder-Artist at Work in His Shop

Fig. 2—Mr. F. F. Nichols Inspecting Some Examples of His Skill with the Oxyacetylene Welding Blowpipe

ken. Cattle-branding, rough riding, the fast prairie stage and other object episodes of the past come to life under his welding blowpipe.

ANNUAL MEETING

The Annual Meeting of the AMERICAN WELDING SOCIETY will be held in Chicago during the week of October 23, 1939. The National Program Committee are already holding meetings planning the papers for the particular sessions. Any member of the Society desiring to present a paper should at once notify Mr. W. Spraragen, Secretary of the National Program Committee, at 33 West 39th Street, New York, N. Y.

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Victor Equipment Company 123
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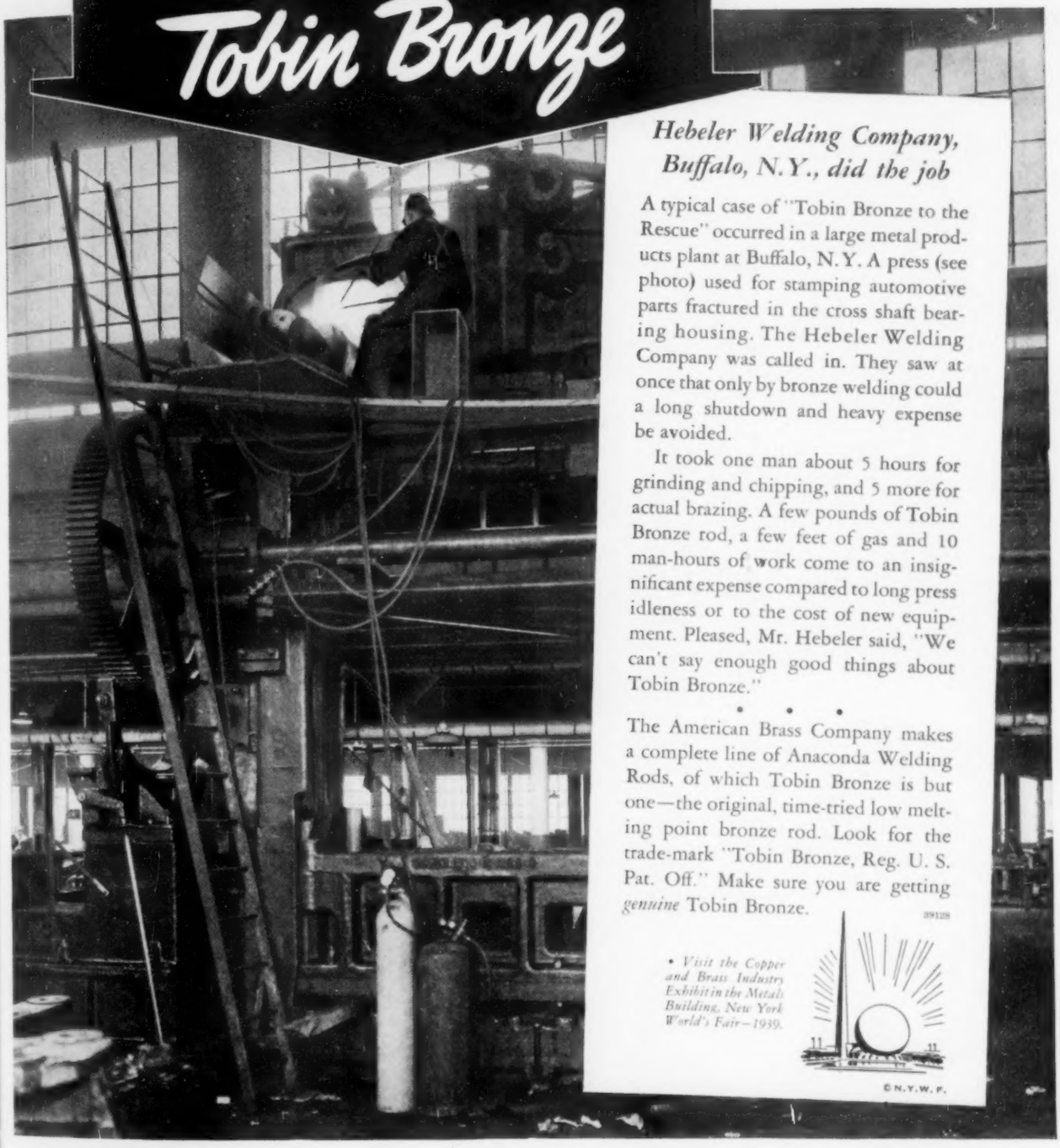
Press saved from long idleness by *Tobin Bronze*



Hebeler Welding Company, Buffalo, N.Y., did the job

A typical case of "Tobin Bronze to the Rescue" occurred in a large metal products plant at Buffalo, N.Y. A press (see photo) used for stamping automotive parts fractured in the cross shaft bearing housing. The Hebeler Welding Company was called in. They saw at once that only by bronze welding could a long shutdown and heavy expense be avoided.

It took one man about 5 hours for grinding and chipping, and 5 more for actual brazing. A few pounds of Tobin Bronze rod, a few feet of gas and 10 man-hours of work come to an insignificant expense compared to long press idleness or to the cost of new equipment. Pleased, Mr. Hebeler said, "We can't say enough good things about Tobin Bronze."

• • •

The American Brass Company makes a complete line of Anaconda Welding Rods, of which Tobin Bronze is but one—the original, time-tried low melting point bronze rod. Look for the trade-mark "Tobin Bronze, Reg. U. S. Pat. Off." Make sure you are getting *genuine* Tobin Bronze.

391128

• *Visit the Copper and Brass Industry Exhibit in the Metals Building, New York World's Fair—1939.*

ANACONDA

Anaconda Welding Rods

THE AMERICAN BRASS COMPANY, General Offices: Waterbury, Connecticut

In Canada: Anaconda American Brass Ltd., New Toronto, Ont. • Subsidiary of Anaconda Copper Mining Company

WELDING CONFERENCE AND SHORT COURSE

Oklahoma, March 9-10, 1939

The program will consist of four technical sessions:

1. Welding and Cutting Technique and Processes
2. Weld Inspection and Testing
3. Welding Costs and Economics
4. Welding and Cutting Applications

Also:

Demonstrations of welding and cutting, arc and gas, on ferrous and nonferrous metals and alloys.

Exhibits of the latest equipment available for welding and cutting.

Space is available to manufacturers wishing to arrange an exhibit.

Address all inquiries to Wm. T. Tiffin, College of Engineering, University of Oklahoma, Norman, Oklahoma.

SAMPLING AND ANALYSIS OF CARBON AND ALLOY STEELS

By Chemists of the United States Steel Corporation. Reinhold Publishing Corp., New York. 556 pp. $4.50

Authoritative and detailed procedures for the analysis of steel products are lucidly presented in this volume. Its aim is to enable any chemist to determine with absolute exactness the composition of any sample. Since steel products are bought and sold on the basis of exact specifications, reliable analytical procedures which can be used throughout the industry are vitally necessary. Careful observance of the directions given will not only reduce the time of determination to a minimum, but will yield absolutely accurate results. Since large-scale production of alloy steels is a comparatively recent development, the need for standardized and authoritative methods of analysis is greater now than ever before, and will be constantly increasing.

The U. S. Steel Corporation has long been prominent in making available to industry everywhere information dealing with testing of materials used and produced in the iron and steel industry.

The scope of this book includes approved procedures for sampling mill products and for determining all the elements that may occur in steel under any conditions of combination.

WELDING FITTINGS

A draft of a proposed American Standard for Welding Fittings has recently been completed by Subgroup No. 6 on Welding Fittings of Subcommittee No. 3 on Steel Flanges and Flanged Fittings of Sectional Committee (B16) on the Standardization of Pipe Flanges and Flanged Fittings. This proposal covers the over-all dimensions of fittings as designed for butt-welded joints, such as elbows and tees, caps and lapped-joint stud ends, reducers and return bends. It covers also the pressure ratings, size, marking, material, metal thickness, tolerance and welding bevel. This proposal is now being distributed to industry for criticism and comment. Copies are available on application. All communications should be addressed to Mr. C. B. LePage, Assistant Secretary, The American Society of Mechanical Engineers, 29 West 39th Street, New York, N. Y.

The standardization of welding fittings is a part of the project assigned to the Sectional Committee on the Standardization of Pipe Flanges and Fittings (B16) of which Dr. Collins P. Bliss is chairman and Mr. J. J. Harman is secretary. The committee was organized under the procedure of the American Standards Association in 1921 with the Heating, Piping and Air Conditioning Contractors National Association, the Manufacturers Standardization Society of the Valve and Fittings Industry, and The American Society of Mechanical Engineers, as joint sponsors. In all, thirty national organizations are cooperating in this project.

NEW PRODUCTS

The Society assumes no responsibility for the validity of claims in this Section

NEW TWO-STAGE REGULATORS

The Linde Air Products Company, Unit of Union Carbide and Carbon Corporation, announces three new regulators: the Purox Oxygen Regulator, Type R-201 (for ordinary welding and light cutting): the Purox Oxygen Regulator, Type R-202 (for heavy-duty cutting): and the Purox Acetylene Regulator, Type R-203.

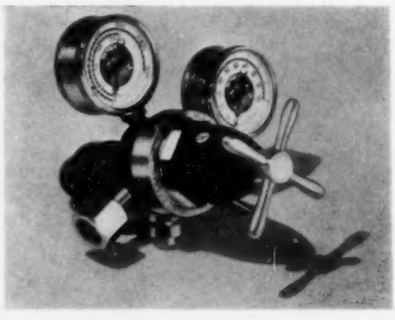


Fig. 1—The Purox Oxygen Regulator, Type R-201, Is for Ordinary Welding and Light Cutting

These regulators utilize the principle of two-stage regulation. A fixed "first stage" reduces the pressure of oxygen or acetylene from cylinder pressure to a moderate figure, below which it is regulated by the variable second stage of regulation. Stem-type valve mechanisms insure a uniform flow of oxygen and acetylene at the lower pressures at which the gases are used and in quantities sufficient for practically all welding and cutting operations.

LEATHER GLOVES FOR WELDERS

The Industrial Gloves Co., 750 Garfield Blvd., Danville, Ill., has recently added a new chrome tanned leather welder's glove to its line of safety clothing. This new gauntlet glove, designated as No. 13115, is made with one-piece back, extending from knuckles to top edge of gauntlet, eliminating all seams on back

of hand which quite frequently rip or burn out on ordinary gloves.

The glove is cut on extra full pattern so that the operator is assured of cool, comfortable protection at all times. The thumb seam is protected with extra leather strap.

NEW WELDING GENERATOR

A patent on a new pulsating direct current welding generator has been secured by E. S. Hebeler of the Hebeler Welding Company, Buffalo, N. Y. It is claimed that this generator is just as effective in eliminating magnetic blow of the arc as alternating current while still possessing the advantages of D. C. current.

SYMPOSIUM ON IMPACT TESTING

The Symposium on Impact Testing, held at the 1938 A. S. T. M. annual meeting, in cooperation with the Welding Research Committee concentrated on two of of the most important phases of the subject, first, the present fields of commercial use for the impact test with particular reference to places where it gives necessary information not supplied by static tests, and second, the basic theory of the test. Nine extensive technical papers and discussions comprise the 170 page symposium book.

Utility and non-standard impact testing, problems in the field of plastics, practical application of the notched-bar impact test, and use of the Charpy test as a method of evaluating toughness adjacent

One "Weak Sister"
cripples the whole crew . . .

Are "Weak Sister" Welding Electrodes Slowing up Your Production?

Most plants have "weak sisters" somewhere along the production line.

Often these "weak sisters" are slow machines that hold up production. Sometimes they are inaccurate machines that cause excessive spoilage.

But—in many cases they aren't machines at all. The weakest of all "weak sisters" are frequently electrodes—spot welding tips, seam welding wheels, flash welding dies!

Are tips that mushroom quickly causing expensive delays for redressing and changing in your plant? We suggest you change to electrodes of Mallory 3 Metal, Elkaloy, Elkonite—or another of the Mallory alloys best suited to your particular job.

Are fast-wearing wheels, or dies that need frequent replacement, the "weak sisters" that lower your production? Why not replace their *weakness* with the *strength* that Mallory offers?

Because of their great hardness, Mallory electrodes resist wear to a remarkable degree, yet provide the highest electrical and thermal conductivity. That's why you'll appreciate—and profit by—their super-service in long, hard production runs.

Mallory metallurgists welcome the opportunity to aid in the application of the *right* resistance welding electrode for your job.

P. R. MALLORY & CO., INC.
INDIANAPOLIS, INDIANA
Cable Address — PELMALLO

P. R. MALLORY & CO. Inc.
MALLORY

RESISTANCE WELDING ELECTRODES

to welds are covered in separate papers, followed by data on stress-strain relations under tension impact loading and a discussion of the theory of impact testing, involving the influence of temperature, velocity of deformation and form and size of specimen on work of deformation. There are some general considerations on the impact testing problems; then a review of the literature on impact testing of welded joints is given and finally a resumé of notched-bar testing and impact testing.

The publication contains a great deal of valuable information and data in the form of tables and charts. Copies in heavy paper cover are available from A. W. S., at $1.25 per copy, non-members and 75¢ to members.

NEW LIGHT-WEIGHT TANK TRAILER HAS HIGH LOAD CAPACITY

A new tank trailer, designed for the Dairymen's League Cooperative Association by the Edward G. Budd Manufacturing Company, weighs only 9100 pounds, yet has a maximum axle loading of 22,400 pounds.

The capacity of the unit is 3600 gallons of milk. This is one of four such trailers which will be operated in New York State by Dairylea.

The chassis is fabricated of stainless steel by the "Shotweld" process and consists of an outside skirting with deep bulkheads extending from side to side for the support of the tank. Because the chassis is located where a skirting ordinarily is used on conventional equipment of this type, considerable weight saving has been realized. In addition, by locating the structural material at this point, it is possible to obtain an increased beam depth, thereby increasing the stiffness of the structure over conventional frame design.

The tank for this unit was fabricated by Standard Steel Works. It consists of a stainless steel interior shell with an aluminum exterior shell. The unit is powered by a Mack tractor.

STEEL CONDITIONING

The Air Reduction Sales Company, Lincoln Building, New York, has just issued a very attractive bulletin on Oxy-acetylene Deseaming Torch, which describes flame scarfing.

Surface conditioning of steel blooms, slabs and billets preparatory to finish rolling has always presented a major problem to the practical steel producer. Necessity of removing cracks, seams, scabs and crows'-feet from steel stock to avoid surface imperfections in the finished product, has required chipping with the pneumatic chisel—a costly and time-consuming operation—on the steel maker. This operation requires large storage space for semi-finished stock, and involves delays in the rolling program, due to classifying and reassembling parts of heats that have been set aside for chipping.

List of New Members

December 1 to December 31, 1938

BIRMINGHAM

Cain, J. (C), Cain's Mach. Shop, Box 238, Tuscaloosa, Ala.

BOSTON

Cooper, Sidney B. (B), Gerstein & Cooper Co., 1 W. 3rd St., South Boston, Mass.
Dand, Raymond J. (B), 25 Waldron Road, Braintree, Mass.

CANADA

Dembitsky, Thomas (B), 622 St. Joseph St., Lachine, Que., Canada.
Dion, Ralph J. (D), Malahat Lumber Co., Port Renfrew, B. C.
Rozon, W. A. (D), 4107 Richelieu St., Montreal, Que., Canada.

CHATTANOOGA

Gentry, W. W. (D), 3915 Gleason Drive, Chattanooga, Tenn.

CHICAGO

Ardagh, J. C., (C), The Lincoln Elec. Co., 1455 W. 37th St., Chicago, Ill.
Bradley, R. B. (C), 12813 Wallace St., Chicago, Ill.
Burks, R. H. (C), 618 Western Ave., Glen Ellyn, Ill.
Culbertson, R. P. (D), 10019 So. Vernon St., Chicago, Ill.
Danielson, L. G. (C), 20 No. Wacker Drive, Chicago, Ill.
Drall, George J. (D), 1849 S. 55th Court, Cicero, Ill.
Fassero, Frank (C), 2733 So. 62nd Ave., Cicero, Ill.
Freeman, Harry W. (D), 6347 Drexel Ave., Chicago, Ill.
Gergits, William (D), 5359 So. Wells St., Chicago, Ill.
Hansen, Carl (D), 3002 Clinton Ave., Berwyn, Ill.

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ALMARC FLUX
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MANGANAL

11 to 13½% Nickel Manganese Steel

WELDING ELECTRODES, WEDGE and APPLICATOR BARS

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Request Catalog

IN the heart of the great Southwest—deep among the world's largest oil fields and petroleum refineries—among sulphur mines, cotton and iron-product industries, and steel-fabricating plants—lies Houston. Here, where the oxy-acetylene process has many of its most important applications, the 39th Convention of the International Acetylene Association will be held, with headquarters at the Rice Hotel, on March 8, 9 and 10, 1939.

Well-known engineers and practical operators—all recognized leaders and authorities in their respective fields—will present papers on such subjects as oxy-acetylene welding, cutting, surface hardening, machine cutting, hard surfacing, and pipe fabrication. Panel discussions, round table meetings, and actual demonstrations also will add to the broad educational aspects of the Convention. Here, you can trade thoughts which will help you develop money-saving and money-making ideas.

Plan Now to Attend

If you have attended I.A.A. Conventions during recent years, you will want to come again. If you have never attended an I.A.A. Convention, you owe it to yourself and your business to find out how interesting and valuable these conventions are to users of the oxy-acetylene process.

Everybody Welcome

All I.A.A. Convention sessions are open to everyone interested in the operation or application of the oxy-acetylene process. There is no registration fee. Write to the Secretary now for an advance copy of the complete program. It will be sent to you as soon as it is off the press.

INTERNATIONAL ACETYLENE ASSOCIATION

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Lyons, L. (D), 15808 Holsted St., Harvey, Ill.
Mann, G. T. (C), The Lincoln Elec. Co., 1455 W. 37th St., Chicago, Ill.
Mayer, Frederick C. (D), 1532 N. Mason Ave., Chicago, Ill.
Moore, James H. (D), 15618 Center Ave., Havey, Ill.
O'Day, L. W. (C), The Lincoln Elec. Co., 1455 W. 37th St., Chicago, Ill.
Paul, Joseph (D), 4139 West End Ave., Chicago, Ill.
Pender, Warren (D), 4647 N. Clark St., Chicago, Ill.
Schwon, Paul (D), 8938 Blackstone Ave., Chicago, Ill.
Zoll, H. W. (D), 4213 N. Mason Ave., Chicago, Ill.

CINCINNATI

Snider, Robert R. (D), 543 Grafton Ave., Dayton, Ohio.

CLEVELAND

Brown, Irving C. (C), 2010 E. 102nd St., Cleveland, Ohio.
Gillespie, A. J. (B), Thew Shovel Co., Lorain, Ohio.
Graham, John (C), American Steel & Wire Co., Rockefeller Bldg., Cleveland, Ohio.

CONNECTICUT

Flanigan, J. G. (C), 1510 Norman St., Bridgeport, Conn.

DETROIT

Dodge, Paul E. (D), 14526 Welland Ave., Detroit, Mich.

MARYLAND

Blakey, Robert M. (D), 3718 Beehler Ave., Baltimore, Md.

MILWAUKEE

Keating, L. M. (B), A. O. Smith Corp., Milwaukee, Wis.
Millette, Millard M. (C), Y. M. C. A., Milwaukee, Wis.
Pollei, Harold O. (D), 3846 N. 24th Place, Milwaukee, Wis.

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Blind, George G. (C), 5 Central Ave., Clifton, N. J.
Doyle, James H. (C), P. O. Box 484, Jersey City, N. J.
Feiner, Mark A. (B), P. Feiner & Sons, Inc., 552 W. 52nd St., New York, N. Y.
Fraser, Robert H. (C), 251 E. 52nd St., New York, N. Y.
Hoinighausen, John (C), 400 Kingsland Ave., Brooklyn, N. Y.
Oelhaf, Carl (C), 177 Christopher St., New York, N. Y.

NORTHERN NEW YORK

Meyers, Edwin J. (C), General Electric Co., 100 Woodlawn Ave., Pittsfield, Mass.

NORTHWEST

Westin, Edward (B), Twin City Lines, Snelling & University Ave., St. Paul, Minn.

OKLAHOMA CITY

Krisman, J. M. (C), Hart Welding Supply Co., Oklahoma City, Okla.
Rickel, F. J. (B), Big Three Welding Equip. Co., Oklahoma City, Okla.

PEORIA

Blome, Henry A. (D), 408 Bootz Ave., Peoria, Ill.
Crouch, Cleer (D), 103 Illinois St., Chillicothe, Ill.
Le Tourneau, Richard L. (B), R. G. Le Tourneau, Inc., 220 Grant St., Peoria, Ill.
Runkel, Alfred (C), R. G. Le Tourneau, Inc., Ft. of Grant St., Peoria, Ill.
Schlis, William J. (D), 305 Hillyer Place, Peoria, Ill.
Shearburn, W. C. (C), 207 Le Tourneau Court, Peoria, Ill.
Smith, T. A. (D), 207 Dayton St., Peoria, Ill.
Warnke, Eldon (C), 129 Pierson St., E. Peoria, Ill.
Watkins, Harry (C), 509 Hayword St., Peoria, Ill.

PHILADELPHIA

Gibb W. H. (B), Thomson-Gibb Elect. Welding Co., 101 N. 33rd St., Philadelphia, Pa.

PITTSBURGH

Sohn, Jesse S. (D), Leetsdale, Pa.

ROCHESTER

Sears, Clifford M. (C), R. C. Neal Co., Inc., 46–48 Andrews St., Rochester, N. Y.

SAN FRANCISCO

Conor, Frank (D), Box 408, S. San Francisco, Calif.

SAN JOAQUIN

Meyer, Paul K. (C), Box 122, Bakersfield, Calif.

SOUTH TEXAS

Brown, R. S. (D), Texas & New Orleans Ry. Co., 324 S. P. Bldg., Houston, Texas.

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Despain, Harry F. (D), 4540 W. 41st St., Tulsa, Okla.
Grubbs, Charles F. (D), General Delivery, West Tulsa, Okla.
Phelps, C. E. (D), R. R. 8, Box 661, Tulsa, Okla.
Wilder, Arthur L. (D), 4749 W. 41st St., Tulsa, Okla.

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Kenny, John F. (B), 5200 Wisconsin Ave. N. W., Washington, D. C.
Yeomans, Alfred H. (C), 3324—19th St., N. W., Washington, D. C.

WICHITA

Van Horn, V. C. (D), Maize Garage, Box 145, Maize, Kans.

YOUNGSTOWN

De Nicholas, Joseph (D), 349 N. Truesdale Ave., Youngstown, Ohio.

NOT IN SECTIONS

Godfrey, G. C. (B), Secretary of Marine, Wellington, N. Z.
Harmon, W. R. (C), Freeport Sulphur Co., Port Sulphur, La.

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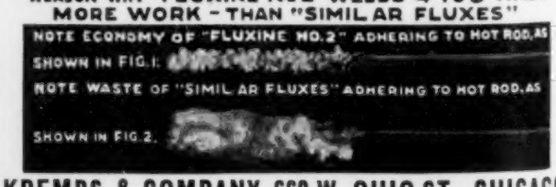
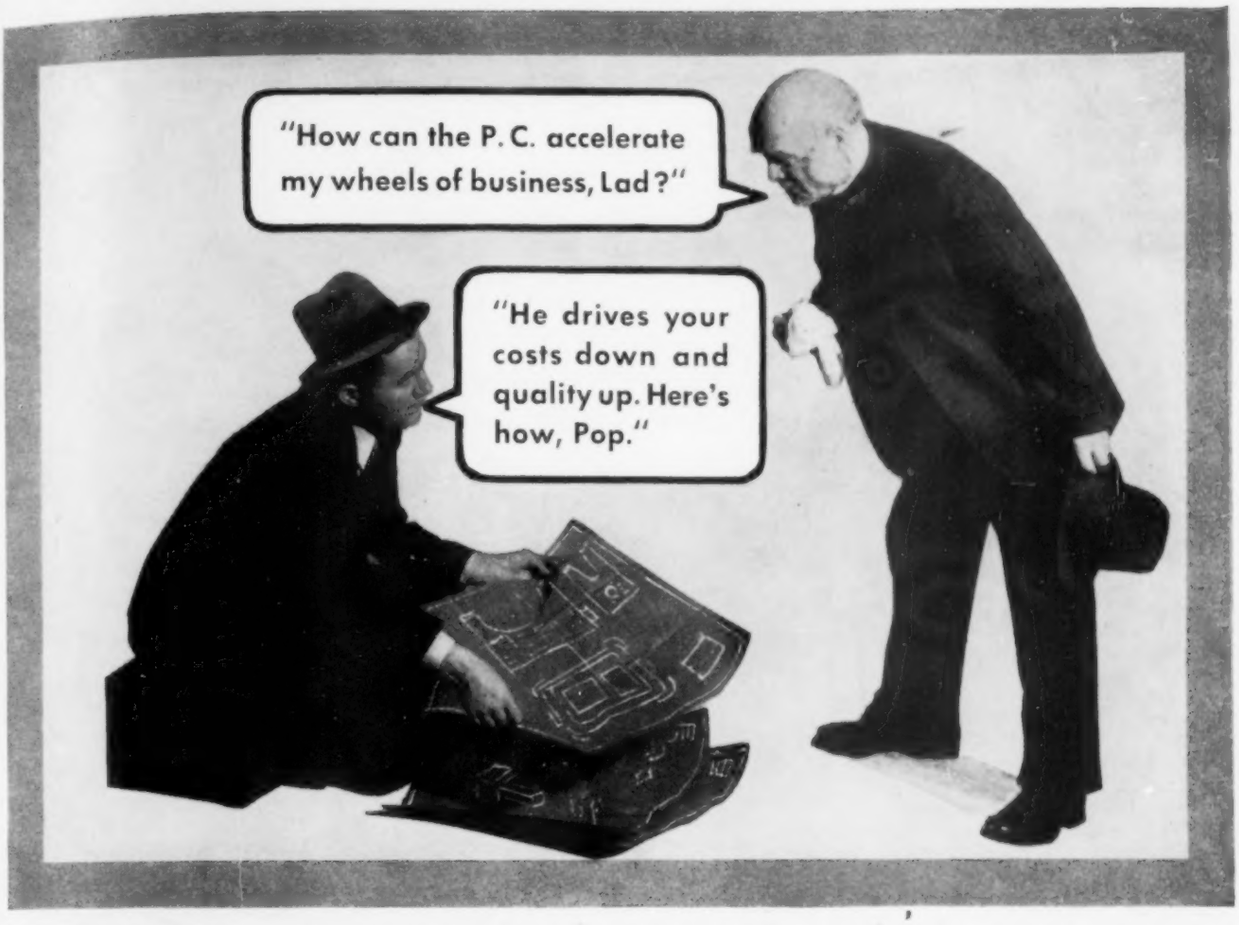
REASON WHY - FLUXINE Nº2 WELDS 4 TO 5 TIMES MORE WORK - THAN "SIMIL AR FLUXES"


NOTE ECONOMY OF "FLUXINE NO. 2" ADHERING TO HOT ROD, AS SHOWN IN FIG. 1.
NOTE WASTE OF "SIMIL AR FLUXES" ADHERING TO HOT ROD, AS SHOWN IN FIG. 2.

KREMBS & COMPANY, 669 W. OHIO ST., CHICAGO



HOW YOU CAN PROFIT MOST WITH WELDING

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squeaks from their wheels of business.

"The plan is simply this: Call to arms a crusading executive with a yen for welding and give him the authority to 'go to town.' Since the results of his efforts are increased profits, we call him the Profit Crusader, or P. C.

"Here is an example of the work of the Profit Crusader in one plant. The part is an axle of a hay rake, formerly consisting of an assembly of castings and truss rod which frequently became loose in service, requiring repair. The Profit Crusader took an angle iron, flat bar and plate and welded them into a permanently rigid unit. The farmer got a shimmy-proof hay rake and the manufacturer saved 30% on the part.

"There's an attractive booklet

available for the asking which gives some valuable suggestions for the Profit Crusader. Write for a free copy. And by all means, get in touch with the nearest Lincoln office. These people will do you and your wheels of business many a good turn."

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Woods, Wylie (D), Wylie Woods Mach. Wks., 127 S. Hall St., Princeton, Ind.

EUROPEAN WELDING PRACTICE AND AMERICAN TRENDS

By Chas. H. Jennings*

Welding in Europe has grown to be as important a tool in engineering as it is in the United States.

Welding machines in Europe are of high quality and in most countries the use of a-c equipment far surpasses the use of d-c equipment. Special attention has been directed to low rating machines for thin gage welding with the consequence that very excellent a-c and rectifier type sets have been developed for this work.

Welding electrodes in Europe are primarily of the shielded-arc type although considerable quantities of bare and light dipped electrodes are still in use in Germany and France.

Spot and other types of resistance welding are not in as common use as they are in America. There is a great interest in this method of welding, however, particularly for automobile, aircraft and railway construction. Auto manufacturers are at the present time considering installation of tube controlled equipment for the production of duraluminum bodies.

Gas welding, cutting and brazing are in common use and very high grade results are being obtained on all types of metals.

The industries in which welding is being used compare with those in the United States. Ships, buildings, bridges, railway coaches, autos, buses, elevators, pressure vessels and all engineering equipment are now being fabricated by welding.

Although welding is used in nearly every field of engineering, future possibilities both in Europe and America indicate that its development in the future will be even greater than in the past.

* Engineer in Charge of Welding Research, Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pennsylvania.

OUR PRESIDENT ON THE MOVE!

Our President is a difficult man to catch.

The reason is evident from a study of his schedule.

October 21st—New York
First Board of Directors Meeting
November 9th—Cincinnati, Ohio
"Field Welded Tanks"
November 10th—Detroit
"Large Welded Tanks of Cylindrical, Spherical and Spheroidal Shapes"
November 11th—Columbus, Ohio
"Large Welded Tanks of Cylindrical, Spherical and Spheroidal Shapes"
November 17th—Niagara Falls, N. Y.
"Field Welded Tanks"
November 18th—Chicago Section
(President's Night)
"Welded Steel Spheres, Spheroids and Elevated Tanks"
December 1st—New York
Executive Committee Meeting
December 6th—Oklahoma City, Okla.
(President's Night)
"Qualification Rules and Welding Research"
December 7th—Tulsa, Okla.
"Field Welded Tanks"
December 14th—Minneapolis, Minn.
January 11th—New York
A.P.I.-A.W.S. Joint Committee
January 12th—New York
Executive Committee Meeting
January 16th—Chicago
(Armour Institute "Process & Operator Qualifications" Lecture Course—A.W.S.) and "Elevated Tanks"
January 18th—Birmingham, Ala.
A.W.S. plans for coming year.
January 27th—Milwaukee, Wis.
"Large Field Welded Tanks"
February 8th—Cleveland
"Large Tanks of Cylindrical, Spherical and Spheroidal Shapes"
February 16th—New York
Executive Committee Meeting
March 28th—Washington, D. C.
"Welded Storage Tanks"

NICKEL CLAD STEEL PLATE

A very attractive technical bulletin entitled "Methods for the Fabrication of Nickel Clad Steel Plate" by F. B. Huston of the International Nickel Company and T. T. Watson of the Lukens Steel Company, has been prepared by the Lukens Steel Company. This pamphlet thoroughly covers every phase of the subject.

» » » SECTION ACTIVITIES « « «

BIRMINGHAM

There was a total attendance of 120 at the November 7th meeting of the Birmingham Section held in the Alabama Power Bldg. Auditorium. Mr. Leon C. Bibber, Welding Engineer, Carnegie-Illinois Steel Corp., gave a most interesting and instructive talk on "Welded Joints—Which Ones to Use and When and Why." Those present were very liberal with questions, resulting in a good round table discussion. There was also a sound motion picture "Cor-Ten Steel" shown through the courtesy of the United States Steel Corporation.

At the December 3rd meeting there was an attendance of 45. This small attendance was accounted for in a large measure because the meeting was held on a Saturday night. Mr. E. E. Isgren, Supt., R. G. LeTourneau, Inc., presented an interesting illustrated talk on "Arc Welding Heavy Road-Building Machinery."

BOSTON

The meeting on January 16th was held

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Fort Wayne, Indiana

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WELDING EQUIPMENT DIVISION

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VICTOR DISTRIBUTION POINTS FROM COAST TO COAST GIVE OVERNIGHT SERVICE

in Room 4–270 at the Massachusetts Institute of Technology and the following interesting program was presented: Mr. Everett Chapman, President of Lukenweld, Inc., discussed the "Analysis of Welding Joints" and Professor A. V. de Forest of the Department of Mechanical Engineering, M.I.T., spoke on the subject of "Stress Concentrations and Strain Raisers in Welds."

CLEVELAND

The Cleveland Section has recently appointed a committee to prepare and present to the City Council for approval and incorporation in the City Building Code, a code which will be in accordance with the AMERICAN WELDING SOCIETY Code on this subject.

The regular monthly meeting of the Cleveland Section was held in Bingham Hall, Case School of Applied Science, on January 11, 1939. Dr. George V. Slottman, steel mill and combustion engineer with the Air Reduction Sales Company, was the guest speaker. His subject was on "New Developments in Cutting and Flame Hardening."

CONNECTICUT

New Officers elected by the Connecticut Section are the following:

Chairman—I. T. Hook, American Brass Co., Ansonia, Conn.

Vice-Chairman—J. J. Vreeland, Chase Brass and Copper Co., Waterbury, Conn.

Treas.—James Mitchell, Farrel-Birmingham Co., Derby, Conn.

Secy.—H. A. Pennington, A. B. King & Co., 196 Chapel St., New Haven, Conn.

The Connecticut Section reports that it is going ahead quite satisfactorily. At their meeting on January 10th in the General Electric Company's Auditorium at Bridgeport, there were about 130 present and a lively interest was manifested in Mr. Leo Edelson's demonstration lecture on Silver Brazing. It is expected to have Mr. Lincoln of The Lincoln Electric Company as speaker at the meeting on the 7th of February.

DETROIT

The January meeting held on the 19th in the Detroit-Leland Hotel, was addressed by Mr. J. G. Magrath, Specialist, Applied Engineering Department, Air Reduction Sales Company, whose subject was on "Flame Descaling." Mr. Magrath's paper was supplemented by a movie and slides illustrating this operation and by remarks on the latest developments in flame hardening.

INDIANAPOLIS

At the December 16th meeting of the Indianapolis Section, the following officers were elected:

Chairman—J. D. Tebben

Vice-Chairman—A. C. Rasmussen

Treasurer—J. S. Williams

Secretary—R. D. Eaglesfield, Jr.

Program Chairman—L. H. Larson

Representatives on National Membership Committee—R. B. Brant, Alex Spink

Board of Directors—F. M. Crapo, Prof. Beese, J. A. Weiger, R. C. Eaglesfield, P. B. Hall, I. R. Wagner, R. H. Dickson and M. R. Harris.

KANSAS CITY

At a special meeting held on January 9th in the Thomas A. Edison Hall of the Kansas City Power & Light Bldg., Mr. J. F. Lincoln, President of The Lincoln Electric Company, gave a most interesting talk on "Welding *vs.* Prejudice." The meeting was very well attended with an attendance of about 500.

At the regular monthly meeting held on the 17th of January Mr. E. J. Brady, Manager—Stainless and Alloy Division, Hollup Corporation, spoke on "Arc Welding the Stainless Steels."

The following are the programs for the next few meetings:

February 14th—"Flame Hardening," by P. Smith, Air Reduction.

March—H. F. Reinhard of the International Acetylene Assn.

April—K. L. Hansen of the Harnischfeger Corp. (Tentative).

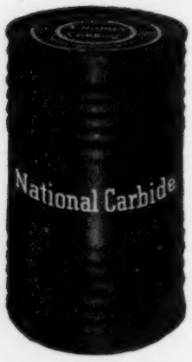
May—C. H. Jennings, Westinghouse Elec. & Mfg. Co. (May 15—tentative date).

MARYLAND

On January 20th at the Engineers' Club, Baltimore, Mr. R. H. Cunningham, as-

National

Carbide



DEPENDABLE

EFFICIENT

ECONOMICAL

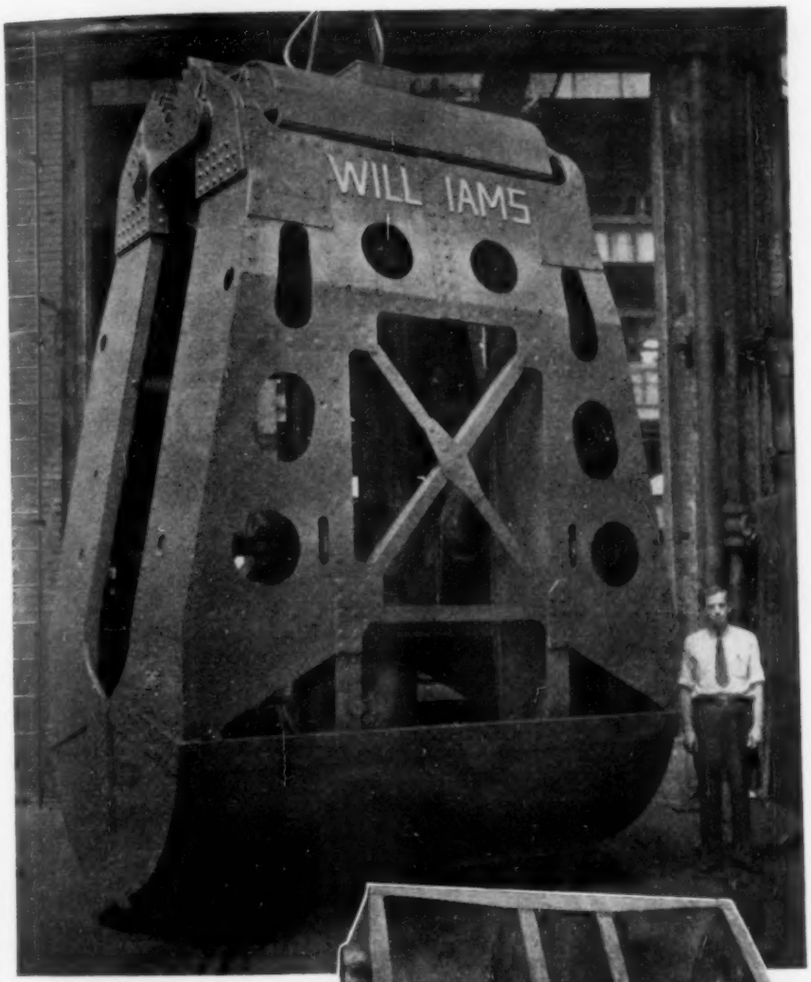
FOR WELDING and CUTTING

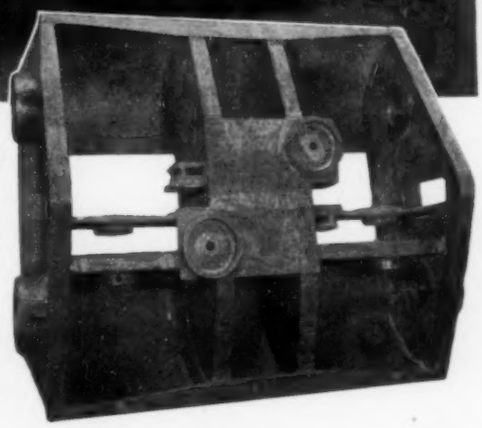
Use National Carbide in the Red Drum

Lincoln Building NATIONAL CARBIDE CORPORATION New York, N. Y.

HOW TO BUILD EQUIPMENT THAT

Won't Break Down!





INSURANCE AGAINST BREAKDOWNS. This clean-up coal bucket with scoops 9 ft. wide and 24 ft. spread is constructed of U·S·S MAN-TEN Rolled Steel throughout. All details, with the exception of the main frame which is unsuited for heat treatment, are welded construction. Dozens of rolled-steel-built buckets like this have proved their ability to stand up under the most severe service. Photographs—Courtesy of the Wellman Engineering Co., Cleveland, Ohio.

LIGHT — UNIFORMLY STRONG THROUGHOUT. Sheave Block for clean-up bucket using MAN-TEN with complete penetration welds (stress relief annealed). This design and the use of High Tensile Steel made substantial saving in weight possible.

Here's one way — *build it of the right kind of* ROLLED STEEL *— used in the right place*

"WRITE your own guarantee against breakage," say the builders of these material handling units. Their clam shell buckets, they claim, are built so strong, so resistant to tension, bending, fatigue and impact that "the customer, in effect, gets an insurance policy with every bucket."

What is their secret of success in building breakdown-proof machinery? Briefly this. These people are specialists in welded rolled steel construction. They know the heartless punishment their equipment must withstand. And, most important of all, they *know* from experience exactly *what kind* of rolled steel to use—and *where* to use it to get the best results.

They use U·S·S COR-TEN where they want to reduce dead weight and increase resistance to atmospheric and brine corrosion . . . U·S·S MAN-TEN to obtain increased strength at low weight . . . U·S·S Abrasion Resisting Steel where abrasive wear is severe . . . other special steels to meet other special needs. They freely combine one steel with another in the same design. Or they combine these steels with castings when such combination seems desirable.

Our experience in helping this fabricating company select rolled steels of the right analysis to simplify fabrication and insure the ultimate in service, is yours for the asking.

CARNEGIE-ILLINOIS STEEL CORPORATION, *Pittsburgh and Chicago*
COLUMBIA STEEL COMPANY, *San Francisco*
TENNESSEE COAL, IRON & RAILROAD COMPANY, *Birmingham*
Columbia Steel Company, San Francisco, *Pacific Coast Distributors* · United States Steel Products Company, New York, *Export Distributors*

UNITED STATES STEEL

sistant to S. O. Jones, Welding Engineer, Newport News Shipbuilding Co., addressed the meeting on "Welding in Shipbuilding and Repair." This address was presented through the courtesy of the Newport News Shipbuilding Co.

NEW YORK

A fine attendance of over two hundred members turned out for the January 10th meeting. Mr. Leon C. Bibber, Welding Engineer of the Carnegie Illinois Steel Co., gave a splendid presentation of the subject of "Impact Testing of Welded Structures," illustrating by lantern slides and motion pictures the results of full scale testing of sections of large ore boats, to determine the relative resistance of the low-alloy steels, Corten and Manten as compared with simple carbon steels to distortion under impact loading.

At the business meeting of the same date, further plans were made regarding the proposed A.W.S. Day at the New York World's Fair tentatively scheduled for a day in May 1939.

OKLAHOMA CITY

In order not to interfere with the holidays, the January meeting of the Oklahoma City Section was held on the second Tuesday of the month instead of the first Tuesday set for regular meeting dates. The meeting was held in the Huckins Hotel, and judging from the large attendance, the change in dates accomplished its purpose.

Mr. Roy Peterson, of the Peterson Welding Laboratories, Emporia, Kansas, was the speaker of the evening and he presented two papers. One on the subject "The Control of Expansion and Contraction by Local Heating," and the other on "Bronze Welding of Cast-Iron Parts."

Most of the talks were accompanied by the frequent use of blackboard illustrations and much comment and discussion followed each paper or talk.

PEORIA

The Peoria Section devoted its January meeting to a "Get Together" banquet and business session held at the Endres Hotel, on January 11th. Since the Section has more than doubled its membership in the last two months, the "mixer" meeting and general reports were considered to be advisable to acquaint the new members with the old members, and to explain the past and future programs.

PHILADELPHIA

The regular monthly meeting of the Philadelphia Section was held on the 16th of January. Mr. F. C. Saacke of Air Reduction Sales Company, gave a review of Oxyacetylene Applications.

The programs for the next few months are as follows:

Feb. 20th—"Residual Stresses," by C. H. Jennings, Westinghouse Elec. & Mfg. Co.

March 20th—"Structural Design and Welding," by F. H. Frankland, American Institute of Steel Construction.

April 17th—"Steel Casting and Plate Fabrication," by C. W. Briggs, Steel Founders Assn. (Joint Meeting with American Foundrymen's Assn.)

May 1939—Annual Inspection Trip.

All of the above with the exception of the inspection trip will be held at the Engineers' Club, Philadelphia, at 8:00 P.M.

A Special Meeting will be held on the 12th of March with the A.S.C.E., on the subject "Structural Design." Speaker is to be announced.

PITTSBURGH

The January 18th meeting was held in the Auditorium of the Mellon Institute of Industrial Research. Mr. F. C. Fantz, Vice-President, Midwest Piping & Supply Co., spoke on "The Fabrication and Installation of Power and Industrial Piping by Welding." The talk was illustrated with slides showing large pressure pipe assemblies both in shop and field.

ST. LOUIS

Mr. R. O. Shive, President, Sterling Steel Casting Co., addressed the January 13th meeting held in the Engineers' Club Auditorium, on "Steel Castings and Their Relation to Welding and Welded Parts." Members of the local section of the American Foundrymen's Association were also invited to attend.

SAN JOAQUIN VALLEY

The December 15th meeting of this Section held in the American Legion Hall, Taft, Calif., had a somewhat reduced attendance of 44 members and guests, due to inclement weather. However, in spite of the poor weather conditions a number of members and guests traveled a distance of some 70 miles to attend the meeting.

Mr. F. W. Church, Engineer of the Fidelity Casualty and Insurance Co., Los Angeles, presented papers that were of vital interest. The subjects covered and explained were, "Welding Requirements Under Order 813E, Boiler Safety Orders of the State of California," also "Requirements for Welding Under Order U69, A. S. M. E. Code." The wide experience of Mr. Church in the field of Pressure Vessel Inspection and his clear insight into the needs of the welding operators and management of a clear and practical interpretation of the Code requirements was most valuable.

Mr. J. E. Beebe of the Hancock Bush Oil Co., Santa Maria, Calif., presented a paper on "Field Welding of Rotary Drill Pipe," which was illustrated with a number of slides taken from photographs of the actual operations involved during the welding of the pipe. His answers to the many questions asked of him were most interesting and proved to be one of the high lights of the evening's program.

SOUTH TEXAS

The Annual Meeting of the South Texas Section was held on December 29th at the Ben Milam Hotel, Houston. At this meeting election of officers for the new term was held. Those elected were:

Chairman—L. H. Courtright
Vice Chairman—B. W. Farquhar
Secretary-Treasurer—Gil V. Dye
Executive Committee—J. M. Hughen, C. W. Cryer, E. E. Dillman, O. E. Berg, Roy Brunt, B. J. Brugge and C. G. Jax.

After the election and introduction of new officers, a letter was read from the Birmingham Section, requesting that the South Texas Section appoint a member to serve on the Southern District nominating committee for the selection of the nominee for the Southern Division Vice-President. After some discussion, Mr. Malcolm V. Reed was nominated to receive this appointment and was appointed to represent the South Texas Section on this nominating committee.

WESTERN NEW YORK

The Executive Committee of the Western New York Section held a dinner meeting at Niagara Falls on January 5th. The meeting was for the purpose of deciding on the activities of the Section for the balance of the year. It was decided that inasmuch as they had an educational course in Buffalo last year, no attempt would be made to have another educational course until next year.

Plans were worked out at this meeting for a strenuous membership drive.

YOUNGSTOWN

The January meeting of the Youngstown Section was held on the 3rd in the Ohio-Edison Auditorium. Mr. L. C. Bibber, Welding Engineer, spoke on the subject, "Welded Joints, Which Ones to Use, When and Why, Costs and Designs."

EMPLOYMENT SERVICE BULLETIN

SERVICES AVAILABLE

A-297. Young man with technical background, recent graduate of welding school (combination course) accredited by U. S. and N. Y. C. Seeks position offering experience and advancement. Starting salary secondary. Prefers vicinity of New York.

A-298. Welder with drafting experience desires position. Graduate of Lincoln Electric School. Also attended Polytechnic.

A-299. Welder desires position. Have had two years' experience in shipyard, all position welding, also automatic welding. Schooling in Gas welding. Can furnish good references. Young man willing to learn and free to go anywhere.

A-300. Welding Specialist, now employed in Sales Field. Seven years practical experience. Arc, Gas, Resistance, Atomic-Hydrogen-Ferrous, Non-Ferrous Metals, every field. Four year sales, demonstrating experience, machines, electrodes. Energetic, dependable. Age 30, single.